DOCUMENT RESUME

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TITLE	Military Curricula for Vocational and Technical Education. X-Ray Specialist, 10-16.
INSTITUTION	Department of the Army, Washington, D.C.; Ohio State Univ., Columbus. National Center for Research in Vocational Education.
PUB DATE	Aug 77
NOTE	1,591p.; The reference manual for this course is available through loan. Contact Dr. Shirley Chase, The National Center Clearinghouse, The National Center for Research in Vocational Education, The Ohio State University, 1960 Kenny Road, Columbus, OH 43210; telephone (614) 486-3655.
EDRS PRICE	MF13/PC64 Plus Postage.
DESCRIPTORS	Allied Health Occupations; *Allied Health Occupations Education; Allied Health Personnel; Course Content; Course Objectives; Curriculum Guides; Learning Activities; Lesson Plans; Postsecondary Education; Radiographers; *Radiologic Technologists; *Radiology; Technical Occupations; *Vocational Education
IDENTIFIERS	Military Curriculum Project

ABSTRACT

These instructor and student materials for a postsecondary course in radiography are one of a number of military-developed curriculum packages selected for adaptation to vocational instruction and curriculum development in civilian settings. This course is designed to provide a working knowledge of radiography that will enable students to perform basic radiographic examinations which meet the standards of the American Medical Association and to provide a quality radiograph to aid physicians in diagnosis. The course consists of five areas of instruction covering 388 hours. Instructional areas include (1) Anatomy and Physiology, (2) Radiographic Physics, (3) Radiographic Positioning, (4) Radiographic Positioning Laboratory, and (5) Special Radiographic Procedures and Techniques. Printed instructor materials include lesson plans and plans of instruction detailing the units of instruction, objectives, duration of lessons, and support materials needed. Student materials include two units of programmed instruction and student handouts. (A reference manual for this course--Radiologic Technology: AFM 160-30; TM 8-280; NAVMED P-5119--is available through loan.) (IRA)

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U.S. DEPARTMENT OF HEALTH,
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This military technical training course has been selected and adapted by The Center for Vocational Education for "Trial Implementation of a Model System to Provide Military Curriculum Materials for Use in Vocational and Technical Education," a project sponsored by the Bureau of Occupational and Adult Education, U.S. Department of Health, Education, and Welfare.

MILITARY CURRICULUM MATERIALS

The military-developed curriculum materials in this course package were selected by the National Center for Research in Vocational Education Military Curriculum Project for dissemination to the six regional Curriculum Coordination Centers and other instructional materials agencies. The purpose of disseminating these courses was to make curriculum materials developed by the military more accessible to vocational educators in the civilian setting.

The course materials were acquired, evaluated by project staff and practitioners in the field, and prepared for dissemination. Materials which were specific to the military were deleted, copyrighted materials were either omitted or approval for their use was obtained. These course packages contain curriculum resource materials which can be adapted to support vocational instruction and curriculum development.

The National Center Mission Statement

The National Center for Research in Vocational Education's mission is to increase the ability of diverse agencies, institutions, and organizations to solve educational problems relating to individual career planning, preparation, and progression. The National Center fulfills its mission by:

- Generating knowledge through research
- Developing educational programs and products
- Evaluating individual program needs and outcomes
- Installing educational programs and products
- Operating information systems and services
- Conducting leadership development and training programs

FOR FURTHER INFORMATION ABOUT
Military Curriculum Materials
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The Ohio State University
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THE NATIONAL CENTER
FOR RESEARCH IN VOCATIONAL EDUCATION
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Military Curriculum Materials for Vocational and Technical Education

Information and Field Services Division

The National Center for Research in Vocational Education

Military Curriculum Materials Dissemination Is . . .

an activity to increase the accessibility of military-developed curriculum materials to vocational and technical educators.

This project, funded by the U.S. Office of Education, includes the identification and acquisition of curriculum materials in print form from the Coast Guard, Air Force, Army, Marine Corps and Navy.

Access to military curriculum materials is provided through a "Joint Memorandum of Understanding" between the U.S. Office of Education and the Department of Defense.

The acquired materials are reviewed by staff and subject matter specialists, and courses deemed applicable to vocational and technical education are selected for dissemination.

The National Center for Research in Vocational Education is the U.S. Office of Education's designated representative to acquire the materials and conduct the project activities.

Project Staff:

Wesley E. Budke, Ph.D., Director
National Center Clearinghouse

Shirley A. Chase, Ph.D.
Project Director

What Materials Are Available?

One hundred twenty courses on microfiche (thirteen in paper form) and descriptions of each have been provided to the vocational Curriculum Coordination Centers and other instructional materials agencies for dissemination.

Course materials include programmed instruction, curriculum outlines, instructor guides, student workbooks and technical manuals.

The 120 courses represent the following sixteen vocational subject areas:

- Agriculture
- Aviation
- Building & Construction Trades
- Clerical Occupations
- Communications
- Drafting
- Electronics
- Engine Mechanics
- Food Service
- Health
- Heating & Air Conditioning
- Machine Shop
- Management & Supervision
- Meteorology & Navigation
- Photography
- Public Service

The number of courses and the subject areas represented will expand as additional materials with application to vocational and technical education are identified and selected for dissemination.

How Can These Materials Be Obtained?

Contact the Curriculum Coordination Center in your region for information on obtaining materials (e.g., availability and cost). They will respond to your request directly or refer you to an instructional materials agency closer to you.

CURRICULUM COORDINATION CENTERS

EAST CENTRAL
Rebecca S. Douglass
Director
100 North First Street
Springfield, IL 62777
217/782-0759

MIDWEST
Robert Patton
Director
1515 West Sixth Ave.
Stillwater, OK 74704
405/377-2000

NORTHEAST
Joseph F. Kelly, Ph.D.
Director
225 West State Street
Trenton, NJ 08625
609/292-6562

NORTHWEST
William Daniels
Director
Building 17
Airdustrial Park
Olympia, WA 98504
206/753-0879

SOUTHEAST
James F. Shill, Ph.D.
Director
Mississippi State University
Drawer DX
Mississippi State, MS 39762
601/325-2510

WESTERN
Lawrence F. H. Zane, Ph.D.
Director
1776 University Ave.
Honolulu, HI 96822
808/948-7834

X-RAY SPECIALIST COURSE

313-91P10

Classroom Course 10-16

Developed by:

United States Army

Development and Review Dates:

August 1977

Occupational Area:

Health

Target Audiences:

Grade 11 - Adult

Print Pages: 2159

Microfiche: 36

Availability:

Curriculum Coordination Centers

Contents:	**Type of Materials:**						**Instructional Design:**				**Type of Instruction:**	
	Lesson Plans:	Programmed Text:	Student Workbook:	Handouts:	Text Materials:	Audio-Visuals:	Performance Objectives:	Tests:	Review Exercises:	Additional Materials Required:	Group Instruction:	Individualized:
Annex A - Anatomy and Physiology	●	●	●		●	x	●		●	x	●	●
Annex B - Radiographic Physics	●		●	●	●	x	●		●	x	●	●
Annex C - Radiographic Positioning	●			●	●		●			x	●	
Annex D - Radiographic Positioning Laboratory	●			●	●		●			x	●	
Annex E - Special Radiographic Procedures and Techniques	●			●	●	x	●			x	●	

X Materials are recommended but not provided.

THE NATIONAL CENTER
FOR RESEARCH IN VOCATIONAL EDUCATION

OSU
The Ohio State University

1960 Kenny Road
Columbus, Ohio 432
(614) 486-3655

Course Description:

This course is designed to provide a working knowledge of radiography which will enable students to perform basic radiographic examinations which meet the standards of the American Medical Association and to provide a quality radiograph to aid physicians in the diagnosis of patients. The course consists of 5 areas of instruction covering 388 hours.

Annex A - Anatomy and Physiology contains 38 lessons covering 81 hours of instruction. The major topic areas with numbers of lessons and instruction hours follows:
- Medical Terminology (1 lesson, 4 hours)
- Introduction to Anatomy (2 lessons, 6 hours)
- Osteology and Radiographic Anatomy of Upper Extremity (9 lessons, 15 hours)
- Osteology and Radiographic Anatomy of Lower Extremity (9 lessons, 14 hours)
- Osteology and Radiographic Anatomy of Vertebral Column and Trunk (4 lessons, 8 hours)
- Internal Anatomy (7 lessons, 17 hours)
- Osteology and Radiographic Anatomy of the Skull (6 lessons, 15 hours)

Annex B - Radiographic Physics contains 25 lessons covering 83 hours of instruction.
- Basic Math Review (1 lesson, 8 hours)
- Theory and Properties X-Rays and Electricity (3 lessons, 9 hours)
- Radiation Protection (3 lessons, 5 hours)
- Radiographic Exposure (7 lessons, 28 hours)
- Film Handling and Processing (5 lessons, 16 hours)
- Electrical Principles and Equipment (7 lessons, 15 hours)

Annex C - Radiographic Positioning consists of 47 lessons covering 62 hours of instruction.
- Introduction and Terminology of Positions (1 lesson, 2 hours)
- Film Identification (1 lesson, 2 hours)
- Exposure Room Orientation (2 lessons, 2 hours)
- Positioning of Upper Extremity (10 lessons, 12 hours)
- Positioning of Lower Extremity (13 lessons, 14 hours)
- Positioning of the Trunk (12 lessons, 16 hours)
- Positioning of the Skull (8 lessons, 13 hours)

Annex D - Radiographic Positioning Laboratory contains 11 lessons covering 125 hours of instruction.
- Machine Orientation (1 lesson, 5 hours)
- Laboratory (8 lessons, 112 hours)
- Laboratory Facilities (2 lessons, 8 hours)

Annex E - Special Radiographic Procedures and Techniques consists of 18 lessons covering 37 hours of instruction.
- Contrast Media (1 lesson, 1 hour)
- Fluoroscopy (1 lesson, 4 hours)
- Special Positioning (3 lessons, 7 hours)
- Special Radiographic Procedures (13 lessons, 24 hours)

This course contains both teacher and student materials. Printed instructor materials include lesson plans and plans of instruction detailing the units of instruction, objectives, duration of lessons, and support materials needed. Student materials include two units of programmed instruction, student handouts. Basic texts are provided; however, suggested films and slides have not been included.

X-RAY SPECIALIST COURSE

Table of Contents

	Page
Course Description	1
Academic Subjects	2
Anatomy and Physiology	6
Radiographic Anatomy and Physiology: Programmed Instruction	14
Two-Way Head Alignments: Programmed Instruction	214
Radiographic Physics	240
Lesson Plans and Student Handouts	250
Radiographic Procedures Basic: General Reference	600
Radiographic Positioning	839
Lesson Plans and Student Handouts	858
Radiographic Positioning: General Reference	
Upper Extremity	1175
Lower Extremity	1217
Trunk	1250
Skull	1285
Radiographic Positioning Laboratory	1312
Lesson Plans and Handouts	1317
Special Radiographic Procedures and Techniques	1366
Lesson Plans and Student Handouts	1373
Technical Manual 8-280	1592

SECTION I - PREFACE

A. Course: 313-91P10, X-Ray Specialist.

B. Purpose: To provide enlisted personnel with a working knowledge of radiography in order for them to perform in a clinical situation at a fixed or field installation, basic radiographic examinations which meet the standards of the American Medical Association and will provide a quality radiograph to aid physicians in the diagnosis of patients. MOS for which trained: 91P10, X-Ray Specialist.

C. Instructional objectives:

*1. Given a radiographic examination request and access to standard equipment, determine the proper patient administration and institute the principles of radiologic technology to produce diagnostic quality radiographs.

a. Operate and maintain with proper safety standards the electromechanical equipment used for diagnostic radiographic examinations.

b. Apply all medical electrical and radiation safety measures when transporting and positioning a patient.

2. Demonstrate knowledge of gross anatomy and physiology in patient handling and positioning.

*3. Completely process radiographic film both manually and automatically.

4. Assist the medical officer in the preparation and management of patients during special examinations.

5. Apply the principles of sterile technique when performing special presurgical radiographic surveys.

7. Apply the knowledge of radiographic physics to obtain a quality diagnostic radiograph.

8. Apply correct radiation protection procedures when using ionizing radiation.

D. Prerequisites: Grade E4 and below. Completion of 300-91B10, Basic Medical Specialist Course. Physical and mental standards IAW AR 611-201, to include: normal color vision, eye-hand coordination, and manual dexterity; normal near vision with or without corrective lenses; no aversion to the sight of blood; and capacity to remain standing for long periods of time. High school diploma or GED equivalency; credit for one year of high school level algebra and one of the basic sciences. Standard score of 100 or higher in aptitude area GT/ST. Special requirements: must be at least 18 years of age upon enrollment; females must not be pregnant. Security clearance is not required. Minimum service time remaining for active duty personnel upon completion of this course: 16 months.

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*Crucial objectives

SECTION III - BODY

ACADEMIC SUBJECTS
TEACHING RESPONSIBILITIES

Division and Subject or Annex Title & Subject	Annex
Anatomy and Physiology:	
Medical Terminology	A
General Osteology and Arthrology	A
Introduction to Anatomy	A
Osteology of the Hand and Wrist	A
Radiographic Anatomy: Hand	A
Osteology of Forearm	A
Osteology of the Humerus	A
Radiographic Anatomy: Forearm and Arm	A
Osteology of the Shoulder Girdle	A
Radiographic Anatomy: Shoulder Girdle	A
Articulations of the Upper Extremity	A
Palpation Points of the Upper Extremity	A
Osteology of the Foot	A
Radiographic Anatomy of the Ankle	A
Osteology of the Leg	A
Osteology of the Femur and Patella	A
Radiographic Anatomy: Leg and Femur	A
Osteology of the Pelvic Girdle	A
Radiographic Anatomy: Pelvis	A
Articulations of the Lower Extremity	A
Palpation Points of Lower Extremity	A
Osteology of the Vertebral Column	A
Osteology of the Thoracic Cage	A
Palpation Points of the Trunk	A
Radiographic Anatomy: Trunk	A
Internal Anatomy: The Urogenital System	A
Internal Anatomy: The Respiratory System	A
Internal Anatomy: The Nervous System	A
Internal Anatomy: The Digestive System	A
Internal Anatomy: The Circulatory System	A
Internal Anatomy: The Endocrine System	A
Osteology of the Skull: The Cranium	A
Osteology of the Skull: The Facial Bones	A
Osteology of the Skull: Practical Exercise	A
Radiographic Anatomy: Skull	A
Palpation Points of the Skull	A
Two-Way Head Alignment of the Skull	A
Radiographic Physics:	
Basic Math Review	B
History of X-Rays	B

SECTION III - BODY (Cont)

Division and Subject or Annex Title & Subject	Annex
Theory and Properties of X-Rays	B
Atomic Structure	B
Introduction to Electricity	B
Radiation Protection	B
Radiation Protection: Specific Biological Effects	B
Radiation Protection: Gonad Shielding	B
X-Ray Tubes and Charts	B
Inverse Square Law	B
Primary Factors of Exposure	B
Accessory Devices	B
Secondary Factors and Film Discussion	B
Compensation Factors	B
Radiographic Exposure Technique	B
Construction and Handling of X-Ray Film	B
Film Holders and Hangers	B
Darkroom Construction	B
Darkroom Processing	B
Artifacts	B
Electricity: Ohm's Law and AC and DC	B
Magnetism and Electromagnetism	B
Transformers and Autotransformers	B
Meters and Timers	B
Rectification	B
X-Ray Machine Circuits	B
Electrical Protection	B
Radiographic Positioning:	
Introduction and Terminology of Positions	C
Film Identification: Captioning	C
Exposure Room Orientation	C
Order of Procedure: Demonstration	C
Positioning of the Upper Extremity: Hand	C
Positioning of the Upper Extremity: Wrist	C
Positioning of the Upper Extremity: Forearm	C
Positioning of the Upper Extremity: Elbow	C
Positioning of the Upper Extremity: Humerus	C
Positioning of the Upper Extremity: Shoulder	C
Positioning of the Shoulder Joint	C
Positioning of the Upper Extremity: Scapula	C
Positioning of the Upper Extremity: Clavicle	C
Film Discussion: Upper Extremity	C
Positioning of the Lower Extremity: Foot	C
Positioning of the Lower Extremity: Os Calcis	C
Positioning of the Lower Extremity: Ankle	C
Positioning of the Lower Extremity: Leg	C
Positioning of the Lower Extremity: Knee	C
Positioning: Knee (Holmblad and Beclere)	C
Positioning: Knee (Settegast)	C
Positioning of the Lower Extremity: Femur	C
Positioning of the Lower Extremity: Pelvis	C
Positioning of the Lower Extremity: Hip	C

SECTION III - BODY (Cont)

Division and Subject or Annex Title & Subject	Annex
Position of the Sacrum	C
Position of the Coccyx	C
Film Discussion: Lower Extremity	C
Positioning of the Trunk: Cervical Spine	C
Positioning of the Oblique, Flexion and Extension Cervical Spine	C
Positioning of the Trunk: Dorsal Spine	C
Positioning of the Trunk: Lumbar Spine	C
Positioning of the Trunk: Lumbosacral Articulation	C
Positioning of the Oblique Sacroiliac Articulation, Oblique Lumbar and Dorsal Spine	C
Positioning of the Trunk: Chest	C
Positioning of the Trunk: Ribs	C
Positioning of the Trunk: Abdomen	C
Positioning of the Sternum	C
Positioning of the Clavicular Joints	C
Film Discussion: Trunk	C
Positioning of the Skull: Cranium	C
Positioning of the Skull: Sinus	C
Positioning of the Skull: Mandible	C
Film Discussion: Cranium-Skull and Supplemental Positions	C
Positioning of the Skull: Mastoid and Temporomandibular Joint	C
Positioning of the Skull: Nose and Facial Bones	C
Positioning of the Skull: Petrous Ridges	C
Positioning of the Skull: Zygomatic Arches and Rhese's Foramen	C
Radiographic Positioning Laboratory:	
Machine Orientation	D
Laboratory: Upper Extremities	D
Laboratory: Lower Extremities	D
Laboratory: Trunk	D
Laboratory: Cranium	D
Laboratory: Esophagus, Stomach Duodenum and Barium Enema	D
Laboratory: Gallbladder	D
Laboratory: Repeat Positions	D
Laboratory: Make Up Positions	D
Laboratory: Spot Film Radiography	D
Laboratory: Darkroom Operations	D
Special Radiographic Procedures and Techniques:	
Contrast Media	E
Fluoroscopy and Image Intensification	E
Examination of the Digestive System	E
Positioning: Stomach, Duodenum, Barium Enema, and Esophagus	E

Division and Subject or Annex Title & Subject	Annex
Positioning: Gallbladder	E
Automatic Processor	E
X-Ray Administration	E
Stereoscopy	E
Vasography	E
Body Section Radiography	E
Prenatal and Pelvimetry	E
Examination of the Urinary System	E
Foreign Body Localization	E
Medical Ethics	E
Soft Tissue	E
Examination of the Nervous System	E
Skeletal Surveys and Scanograms	E
Bronchography and Fluid Levels	E
Pediatric Radiography	E

SECTION IV - ANNEXES

ANNEX A

ANATOMY AND PHYSIOLOGY

OBJECTIVE: Demonstrate knowledge of gross anatomy and physiology in patient handling and positioning.

Subject and LP No	Lesson Objective	References
Medical Terminology LP 38-100-001	List and discuss the components of a medical term. Define selected medical terms. Define and describe terms dealing with directions, planes, surfaces and positions.	TM 8-280, pp 8-1, 8-2, para 8-1 thru 8-3; Dorland.
General Osteology and Arthrology LP 38-100-002	List the components of bone; define and classify the structures found on bone, Describe the stages and types of bone growth, List and define the classification of bone. List the types of fractures. Define joint classifications and movements.	TM 8-280, pp 8-2 thru 8-10, para 8-4 thru 8-10; Gray, pp 26-54. P1-38-100-0020-1 VTR.
Introduction to Anatomy LP 38-100-003	Define various studies of the body to include anatomy, physiology and pathology. Using the terms cell, tissue, organ, organization of the body from the simple cell to the complex organism, list the seven main body systems.	TM 8-280, pp 3-5 thru 3-10, para 3-13 thru 3-20; Dorland.
Osteology of the Hand and Wrist LP 38-100-004	List and locate, using anatomical references, the bones of the hand, List, identify, and describe the structures found on the bones of the hand.	TM 8-280, pp 8-10 thru 8-13, para 8-12; Gray, pp 227-236; VTR.
Radiographic Anatomy: Hand LP 38-100-005	Given any bone of the hand and a radiograph including that bone, analyze the various film densities to locate and identify corresponding anatomical structures.	Meschan, pp 51-60.

7

Subject and LP No	Lesson Objective	References
Osteology of Forearm LP 38-100-006	List and locate, using anatomical references, the bones of the forearm. List, identify and describe the structures found on the bones of the forearm	TM 8-280, pp 8-13, 8-14; para 8-13; Gray, pp 220-227; VTR.
Osteology of the Humerus LP 38-100-007	Using anatomical references, state the location of the humerus. List, identify, and describe the structures found on the humerus.	TM 8-280, p 8-14, para 8-14; Gray, pp 215-220; VTR.
Radiographic Anatomy: Forearm and Arm LP 38-100-008	Given any bone of the forearm or arm, and a radiograph including that bone, analyze the various film densities to locate and identify corresponding anatomical structures.	Meschan, pp 89-112; VTR.
Osteology of the Shoulder Girdle LP 38-100-009	List and locate, using anatomical references, the bones of the shoulder girdle; List, identify and describe the structures found on the bones of the shoulder girdle.	TM 8-280, pp 8-14 thru 8-18, para 8-15; Gray, pp 208-215; VTR.
Radiographic Anatomy: Shoulder Girdle LP 38-100-010	Given any bone of the shoulder girdle, and a radiograph including these bones, analyze the various film densities to locate and identify corresponding anatomical structures.	Meschan, pp 31-42; VTR.
Articulations of the Upper Extremity LP 38-100-011	Discuss and correlate on radiographs the arthrology of the upper extremity. State the normal movements associated with the joints.	VT-790 LP 38-100-011; TM 8-280, p 8-18, para 8-16; Gray, pp 324-346.
Palpation Points of the Upper Extremity LP 38-100-012	Identify and locate the external landmarks of the upper extremity utilized for radiographic positioning and alignment.	TM 8-280, p 8-18, para 8-19; Gray, pp 87-96; VTR.

Subject and LP No	Lesson Objective	References
Osteology of the Foot LP 38-100-013	List and locate, using anatomical references, the bones of the foot. List identify and describe the structures found on the bones of the foot.	TM 8-280, pp 8-19 thru 8-21, para 8-20 and 8-21; Gray, pp 262-275; VTR.
Radiographic Anatomy of the Ankle LP 38-100-014	Given any bone of the foot, and a radiograph including that bone, analyze the various film densities to locate and identify corresponding anatomical structures.	Meschan, pp 85-92.
Osteology of the Leg LP 38-100-015	List and locate, using anatomical references, the bones of the leg. List, identify and describe the structures found on the bones of the leg.	TM 8-280, pp 8-21 thru 8-22, para 8-22; Gray, pp 230-237; VTR.
Osteology of the Femur and Patella LP 38-100-016	Using anatomical references, state the location of the femur and patella, list, identify and describe the structures found on the femur and patella.	TM 8-280, pp 8-22 thru 8-23, para 8-23; Gray, pp 247-254; VTR.
Radiographic Anatomy: Leg and Femur LP 38-100-017	Given any bone of the leg or femur, and a radiograph including that bone, analyze the various film densities to locate and identify corresponding anatomical structures.	Meschan, pp 110-115; VTR.
Osteology of the Pelvic Girdle LP 38-100-018	List and locate, using anatomical references, the bones of the pelvis. List, identify, and describe the structures found on the bones of the pelvis.	VT-34, LP 38-100-018; TM 8-280, pp 8-23, 8-24, para 8-24; Gray, pp 236-247.
Radiographic Anatomy: Pelvis LP 38-100-019	Given any bone of the pelvis and a radiograph including that bone, analyze the various film densities to locate	Mechan, pp 62-63; VTR.

Subject and LP No	Lesson Objective	References
	and identify corresponding anatomical structures.	
Articulations of the Lower Extremity LP 38-100-020	Discuss the arthrology of the lower extremity, state the normal movements associated with the joints discussed.	VT-878, LP 38-100-020; TM 8-280, pp 8-25, 8-26, para 8-25.
Palpation Points of Lower Extremity LP 38-100-021	Identify and locate the external landmarks of the lower extremity utilized for radiographic positioning and alignment.	TM 8-280, p 8-27, para 8-26; VTR.
Osteology of the Vertebral Column LP 38-100-022	List and locate, using anatomical references, the bones of the vertebral column. List, identify, and describe the structures found on the bones of the vertebral column.	TM 8-280, pp 8-27 thru 8-32, para 8-27, thru 8-35; Gray, pp 75-95; VTR.
Osteology of the Thoracic Cage LP 38-100-023	List and locate, using anatomical references, the bones of the thoracic cage. List. identify and describe the structures found on the bones of the thoracic cage.	TM 8-280, pp 8-30 thru 8-35, para 8-37 thru 8-40; Gray, pp 133-145: VTR.
Palpation Point of the Trunk LP 38-100-024	Identify and locate the external landmarks of the trunk utilized for radiographic positioning and alignment.	TM 8-280, p 8-35, para 8-40(b, 3-c); Gray, pp 57-83; VTR.
Radiographic Anatomy: Trunk LP 38-100-025	Given any bone of the trunk and a radiograph including that bone, analyze the various film densities to locate and identify corresponding anatomical structures.	Meschan, pp 170-193; VTR.
Internal Anatomy:	List the function, structure and anatomical location of	VT-1053, LP 38-100-026;

Subject and LP No	Lesson Objective	References
The Urogenital System LP 38-100-026	the organs of the urogenital system, List the organs of the urogenital system in normal and retrograde order; describe the rationale for radiographic examinations of the urogenital system.	TM 8-280, pp 8-52 thru 8-59, para 8-65 thru 8-71; Gray, pp 1265-1330.
Internal Anatomy: The Respiratory System LP 38-100-027	List the function, structure, and anatomical location of the organs of the respiratory system. List the organs of the respiratory system in normal and retrograde order; describe the rationale for radiographic examinations of the respiratory system.	TM 8-280, pp 8-59 thru 8-61, para 8-72 thru 8-80; VTR.
Internal Anatomy: The Nervous System LP 38-100-028	List the function, structure, and anatomical location of the organs of the nervous system. List the organs of the nervous system in normal and retrograde order. Describe the rationale for radiographic examinations of the nervous system.	TM 8-280, pp 8-61 thru 8-66, para 8-81 thru 8-86; Gray, pp 236-247; VTR.
Internal Anatomy: The Digestive System LP 38-100-029	List the function, structure, and anatomical location of the organs of the digestive system. List the organs of the digestive system in normal and retrograde order; describe the rationale for radiographic examinations of the digestive system.	TM 8-280, pp 8-42 thru 8-52, para 8-50 thru 8-64; Gray, pp 1161-1263; VTR.
Internal Anatomy: The Circulatory System LP 38-100-030	List the function, structure, and anatomical location of the organs of the circulatory system. List the organs of the circulatory system in normal and retrograde order; describe the rationale for radiographic examinations of the circulatory system.	TM 8-280, pp 8-66 thru 8-71, para 8-87 thru 8-96; VTR.

Subject and LP No	Lesson Objective	References
Internal Anatomy: The Endocrine System LP 38-100-031	List and locate the nine regions of the abdomen. List the names and abbreviations of the quadrants of the abdomen. List and describe the four body types. List and discuss the endocrine organs, their location and function.	TM 8-280, pp 8-71 thru 8-73, para 8-97 thru 8-106; VTR.
Osteology of the Skull: The Cranium LP 38-100-032	List and locate, using anatomical references, the bones of the skull. List, identify and describe the structures found on the bones of the skull.	TM 8-280, pp 8-35 thru 8-39, para 8-41 and 8-42; Gray, pp 145-194; VTR.
Osteology of the Skull: The Facial Bones LP 38-100-033	List and locate, using anatomical references, the bones of the face. List, identify, and describe the structures found on the bones of the face.	TM 8-280, pp 8-39, 8-40, para 8-43 thru 8-45; Gray, pp 163-208; VTR.
Osteology of the Skull: Practical Exercise LP 38-100-034	Given a human skull, locate, with the use of class notes, the cranial and facial bones and the structures found on each.	TM 8-280, pp 8-40, 8-41, para 8-46 and 8-47; Gray, pp 145-208; VTR.
Radiographic Anatomy: Skull LP 38-100-035	Given any bone of the skull and a radiograph including that bone, analyze the various film densities to locate and identify corresponding anatomical structures.	Meschan, pp 94-130; VTR.
Palpation Points of the Skull LP 38-100-036	Identify and locate the external landmarks of the skull utilized for radiographic positioning and alignment.	TM 8-280 p 8-42, para 8-49; Gray, pp 49-56; VTR.

12

Subject and LP No				Lesson Objective	References
Two-Way Head Alignment of the Skull LP 38-100-037				List and locate the palpation points of the skull. List, define, and locate the reference lines and planes of the skull.	TM 8-280, pp 8-46, 8-47; P1-38-100-016-1

23

13

MODIFICATIONS

LP's #38 100 Annex A of this publication has (have) been deleted in adapting this material for use in Vocational and Technical Education. Deleted material was not available at time of publication and its exclusion does not alter the value of remaining material.

General Reference materials follow.

14

Table of Contents

I. Introduction to Medical Terminology

Selected Medical Vocabulary 1

Weekly Objectives 12A

Directions, Planes, Surfaces, Positions 15

General Osteology 19

General Arthrology 28

Introduction to Anatomy 31

II. Osteology of the Upper Limb

Weekly Objectives 39A

Outline of Upper Limb 40

Osteology of the Hand 41

Osteology of the Forearm 45

Osteology of the Arm 48

Osteology of the Shoulder Girdle 51

Articulations of the Upper Limb 55

Palpation Points of the Upper Limb 57

15

Medical Terminology and Selected Medical Vocabulary

GROUP I

A. Prefixes Indicating Location, Direction, and Tendency

PREFIX	MEANING	EXAMPLE
ab-	away from	abduct
ad-	to, near, toward	adduct
ana-	apart, across, up	anatomy
ante-	before	anterior
com-	with, together	compound
di-	apart from	diarthrosis
dis-	apart from	disarticulation
ecto-	outside	ectoderm
en-	in	encapsulated
endo-	inside	endoderm
epi-	upon, or above	epicondyle
ex-	out, from	exhale
homo-	the same	homogenous
hetero-	different	heterogenous
infra-	under	infraorbital
intra-	within one	intravenous
peri-	around	periosteum
pneumo-	air	pneumothorax
post-	after	posterior
super-	above	supercilliary

16

PREFIX	MEANING	EXAMPLE
sym-	with, together	symphysis
syn-	with, together	synarthrosis
trans-	across	transverse

B. Stems

STEM	MEANING	EXAMPLE
arthro-	joint	arthrology
bursa	a small sac between moving parts	bursitis
chondro-	cartilage	chondrotomy
costal	rib	costal margin
coxa	hip	os coxa
myel-	spinal cord	myelography
osteo-	bone	osteology
pes	foot	pes planus

C. Prefixes Denoting Position

PREFIX	MEANING	EXAMPLE
antero-	in front of	anteromedian
dextro-	right	dextrocardia
latero-	to side of	laterodeviation
levo-	left	levorotation
postero-	behind	posterolateral

D. Selected Medical Vocabulary

ANKLE	A bend or angle
ANTRUM	A cave
APPENDIX	Something hung from or attached to something else

ARTICULATE	Divided into or united by joints
AXIS	(An axle) A line about which any revolving body turns
CANCELLOUS	A grating or lattice work
CAPITATE	A head
CAUDAD	Toward the feet
CEPHALIC	Toward or pertaining to the head
CONDYLE	Knuckle-like
CORTEX	The outer bark or rind
DORSUM	The back
FISSURE	A cleft
FORAMEN	An aperture or hole
LAMINA	A thin plate
MEDULLA	Marrow (Middle)
OS	Bone
RAMUS	A branch
SAGITTAL	An arrow
SINUS	A cavity or hollow space
SPINE	A thorn
TUBERCLE	A bump

GROUP II

A. Prefixes

PREFIX	MEANING	EXAMPLE
amphi-	both	amphibian
anti-	against	antiseptic
cardia-	heart	cardiology
carpus-	wrist region	carpal bone
cerebro-	brain	cerebroangiogram
circum-	around	circumference
con-	with, together	contraction
gastric-	stomach	gastrointestinal
hepatic-	liver	hepatitis
hypo-	under	hypodermic
in-	in	inspiration
inter-	between	intercostal
meta-	beyond, change	metacarpal
para-	beside	paranasal
pre-	before	prenatal
pro-	before	prognosis (forecast)
retro-	backward	retrograde
sub-	under	subclavian
supra-	above	supraorbital

B. Stems

STEM	MEANING	EXAMPLE
angio-	vessel	angiography
chole-	bile	cholecystography

STEM	MEANING	EXAMPLE
myo-	muscle	myology
odont	tooth	odontoid process
phlebo-	vein	phlebitis
phrenic	diaphragm	costophrenic angle
pyelos	kidney pelvis	pyelogram
salpinx	tube	hysterosalpingogram
thorax	chest	thoracic vertebra

C. Selected Medical Vocabulary

ABDOMEN	(To hide) That portion of the trunk which lies between the thorax and the pelvis
CARPUS	Sticks or bits of wood
CORACOID	Like a crow's beak
CUBOID	Cube-like
DELTOID	Triangular in shape
HAMULUS	A little hook
NAVICULAR	Boat-shaped
OBTURATOR	A stopper
PES	Foot
PEDES-	Feet
PISIFORM	Pea-shaped
SCAPHOID	Skiff-(boat) like
SESAMOID	Like a sesame seed
TARSUS	Basket
TIBIA	Pipe or flute, shin bone
UNCIFORM	Hook-shaped

GROUP III

A. Suffixes

SUFFIX	MEANING	EXAMPLE
-able	ability	portable
-ac	related to	cardiac
-cyte	cell	leukocyte
-form	shape	uniform
-gram	a writing	electrocardiogram
-graphy	writing	radiography
-itis	inflammation	appendicitis
-ium	miniature	manubrium
-olus	miniature	gladiolus
-culum	miniature	tuberculum
-logy	study of	pathology
-meter	measure	thermometer
-oid	resembling	cuboid
-oma	a new growth	carcinoma
-osis	condition	tuberculosis
-physis	growth	epiphyseal zone
-stasis	position	metastasis
-therapy	treatment	radiotherapy

B. Operative Terminology

TERM	MEANING	EXAMPLE
-(o)tomy	to cut into	craniotomy
-ectomy	cutting out	appendectomy
-scopy	to look	cystoscopy

C. Prefixes Denoting Color (Chromo-)

PREFIX	MEANING	EXAMPLE
leuko-	white	leukocyte
polio-	gray	poliomyelitis
cyano-	blue	cyanosis
rube-	red	rubescent
erythro-	red	erythrocyte

E. Selected Medical Vocabulary

ACETABULUM	A vinegar cup (From acetum, vinegar + abulum, a little holder)
ALA	A wing
ALVEOLUS	Small space or compartment
ANKYLOSIS	Abnormal immobilization of a movable joint
ANNULUS	A ring, ring-like, or circular structure
CALYX	A cup
CANTHI	Corner of the eye
CORONOID	Crown-like
COSTAL	Rib
CRIBRIFORM	A sieve-like object

22

Selected Medical Vocabulary (Continued)

CRICOID	A ring
CYST	Bladder, fluid filled sac
DIAPHRAGM (PHRENIC)	A partition
LUMBAR	The loin, "small of the back"
ODONTOID	Tooth-like
PARIETAL	A wall
PELVIS	Basin
PYLORUS	A gate keeper
RADIUS	A ray, spokes of a wheel
SELLA TURCICA	Turkish saddle
SIGMOID	S-shaped
SQUAMA	Scale of fish or serpent
STYLOID	Like a stylus, or point of a pen
TROCHANTER	To run
TYMPANUM	A drum

GROUP IV

A. Prefixes Denoting Number and Measurement

PREFIX	MEANING	EXAMPLE
uni-	one	unilateral
mono-	one	monoplane
bi-	two	bilateral
di-	two	dicephalus

33

Prefixes Denoting Number and Measurement (Continued)

PREFIX	MEANING	EXAMPLE
ter-	three	tertiary
tri-	three	triangular
cent-	hundred	centigrade
milli-	1/1000	milliampere
kilo-	1000	kilovolt
demi-	half	demifacet
semi-	half	semiconscious
hemi-	half	hemisphere

B. Prefixes of Negation

PREFIX	MEANING	EXAMPLE
a-	without	atypical
in-	not	incurable
im-	not	immature

C. Selected Medical Vocabulary

ACROMION	Shoulder point
AMBULANT (AMBULATORY)	Walking, or able to walk
APEX	(Plural--apices) Tip, or point of a cone
ARACHNOID	Resembling a spider's web
ASCENDING	Having an upward course

Selected Medical Vocabulary (Continued)

ASTRAGALUS	A die. Greek soldiers made dice from a sheep bone named astragalus. Romans made dice from a horse heel bone called taxillus. Talus and astragalus came to be applied to the same bone in the tarsus because they were used to make dice.
AUDITORY	Sense of hearing
AURICLE	Little ear (Diminutive of ear, aurio)
AUTONOMIC	Self-controlled (Self + law)
AXILLA	Armpit
BRACHIUM	The arm
CECUM	Blind (Dead end)
CALCANEUS	The heel
CAPILLARY	Hair-like
CERVICAL	Neck
CILIUM	Eyelash, little hair
CLAVICLE	A key, or window fastener
CLINOID	Shaped like a bed post
COCCYX	Resemblance to bill of a cuckoo
CONCHA	A shell
CORPUS	Body
CORPUSCLE	Little body
CRISTA GALLI	Crista (A rooster's crest + gallus (A barnyard rooster)
CUNEIFORM	Wedge-shaped
DENS	A tooth
DESCENDING	Extending downward

Selected Medical Vocabulary (Continued)

DUODENUM	Latin for 12--12 finger breadths in length
ENSIFORM	Sword-shaped
FABELLA	A little bean
FEMUR	The thigh
FIBULA	Needle of a broach, calf bone
GALL	The bile
GLABELLA	(Without hair) Space between the eyebrows
GLENOID	Shallow socket
HILUM	Depression--i.e., a depression on a bean
ILEUM	Twisted gut
JEJUNUM	(Fasting) 'Portion of intestine empty after death.'
LACRIMAL	Tear
MALAR	The cheek
MANDIBLE	The lower jaw; from mandere (To chew)
MEDIASTINUM	Median partition
MASTOID	Breast-like
MAMMILLARY	Referring to the breast, or breast-like
NEPHRO-	Kidney
NEURO-	Nerve
OCCIPUT	Back part of the head
PARAPLEGIA	Paralysis of the lower limbs
PATELLA	A small pan, or dish
PETROUS	Rock

Selected Medical Vocabulary (Continued)

POPLITEAL	Back of the knee
RENAL	Kidney
SACRUM	Sacred or holy, bone left to reassemble on the day of resurrection
SCAPULA	Spade
SEPTUM	A dividing wall, a partition
TROCHLEA	A pulley
VENTRICLE	Any small cavity
VERTEBRA	To turn
VOMER	Plowshare
XIPHOID	Sword-like
ZYGOMA	Like a yoke

WEEKLY OBJECTIVES AND GOALS

First Week - Anatomy

By the end of the first week you will be tested on the following objectives. The examination will consist entirely of multiple choice items.

I. Word lists I, II, III (approximately 32% of the exam).

A. Select the response which:

1. Defines a given medical term.
2. Interprets the meaning of a medical term by identifying and defining its components (prefix, stem, and suffix).
3. Identifies the medical term being defined.

II. Medical Terminology (approximately 28% of the exam)

A. Select the best descriptive statement or definition which identifies a medical term concerning a:

1. Direction
2. Body plane
3. Body surface
4. Position of the body or a part as used in radiography

B. Select the medical term which is identified by a descriptive statement or definition concerning a:

1. Direction
2. Body plane
3. Body surface
4. Position of the body or a part as used in radiography

III. General Osteology and Arthrology (approximately 28% of the exam)

A. Select the response which when:

1. Given a component of bone's composition, states the location, purpose, and/or various forms in which it exists.
2. Given the location, purpose, and/or various forms in which a component of bone exists, states which specific component is being described.

B. Select the best descriptive statement or definition which identifies a given:

1. Structure found on bone
2. Bone fracture
3. Joint structure
4. Specific joint movement

C. Select the response which is identified by a descriptive statement or definition concerning a:

1. Structure found on bone
2. Bone fracture
3. Joint structure
4. Specific joint movement

IV. Introduction to Anatomy (approximately 12% of the exam)

A. Select the response which when:

1. Given a science, best describes that science
2. Given the description of a science, states the science being described.
3. Given a component of a complex organism, (cell, tissue, organ, organ system and organism) best describes that component.
4. Given a description of a component in the organization of a complex organism, (cell, tissue, organ, organ system and organism) states which component is being described.

B. Select the response which best states when a cell is most susceptible to damage by x-radiation.

MEDICAL TERMINOLOGY

OBJECTIVES

1. List and discuss the components of a medical term.
2. Define selected medical terms.
3. Define and describe terms dealing with directions, planes, surfaces, and positions.

I. Medical Term

  A. Components

    1. Prefix

    2. Stem

    3. Suffix

B. Examples

C. Common Medical Abbreviations

II. Terms Dealing with Directions, Planes, Surfaces, and Positions

A. Directions

1. __________ ____________ ____________. This position is arbitrarily taken to be an erect (standing) position, with feet flat on the floor, upper limbs at the sides, palms and toes turned __________ and eyes __________.

2. __________ or ventral: Refers to the __________ side of the body, or toward the __________.

3. Posterior or __________: Refers to the ________ or toward the ________ of the body.

4. __________: Toward or nearer the midline of the body.

5. __________: Away from the midline or toward the side of the body.

6. __________: Nearest to a point under consideration. In the case of the limbs the origin (joint) is taken at this point.

7. __________: Remoteness from a point under consideration; the opposite of proximal. In the case of the limbs the origin (joint) is taken as the point of comparison.

8. __________: Above.

9. __________: Below.

10. __________: Toward the head.

11. __________: Toward the feet.

12. __________: Refers to inside or nearer the center.

13. __________: Refers to outside or remote from the center.

14. Common prefixes denoting direction:

    a. ________: Between two.

    b. Intra- : __________.

32

c. Ab-- ____________________ ____________________.

d. ______________________________: Toward

e. ______________________________: Above.

f. Superimpose: To place one directly above another.

g. Infra-- ____________________________.

h. Epi-- ____________________________.

i. Sub-- ____________________________.

j. Hyper--above.

k. Hypo--below.

B. PLANES OF THE BODY

1. ______________________________: Any vertical plane that divides the body into right and left _________________________portions.

2. Median or ___________________________plane: The vertical planes that divides the body into right and left___________________.

3. ___________________________or frontal plane: Any vertical plane that divides the body into front and rear portions.

4. Transverse or _______________________ plane: Any horizontal plane that divides the body into upper and lower portions. The level of this plane must be given.

C. SURFACES

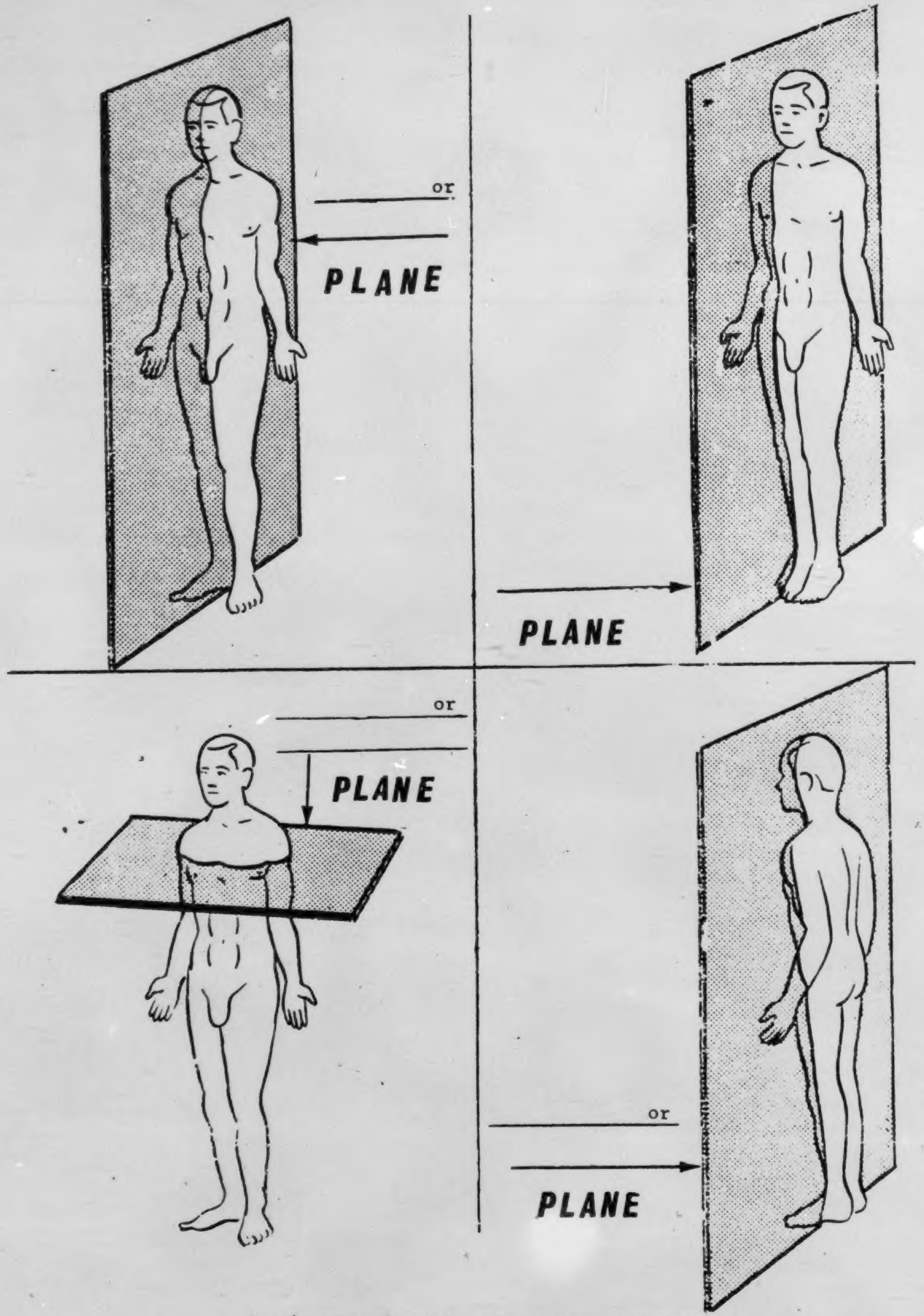
1. ______________________surface: Anterior surface (palm) of the hand.

2. _____________________ surface: Anterior surface of the hand and forearm.

3. _____________________ surface: Inferior surface sole of the foot.

4. _____________________: An outward curvature of a surface.

5. _____________________: An inward curvature of a surface.


or
PLANE
PLANE
or
PLANE
or
PLANE

Normal anatomical position, showing the anatomical planes

D. POSITIONS OF THE BODY AND ITS PARTS USED IN RADIOGRAPHY

1. ________________________position: A horizontal position of the body lying flat on the back. No rotation of the trunk.

2. ________________________. A horizontal position of the body lying face and stomach down. No rotation of the trunk.

3. ________________________decubitus or __________________: A horizontal position of the body lying on either side with no rotation of the trunk.

4. ________________________position: A position of the body or any of its parts when placed on the side. No rotation of the part. The term "right" or "left" refers to the side nearest the x-ray film when the trunk or head are radiographed.

5. _______________________position: A position of the body or any of its parts when placed at an _________________ angle to the x-ray film.

6. Erect or _____________________position: A position of the body either sitting or standing.

GENERAL OSTEOLOGY

Objectives

1. List the components of bone.
2. Define and classify the structures found on bone.
3. Describe the stages and types of bone growth.
4. List and define the classification of bone.
5. List the types of fractures.

I. THE COMPOSITION OF BONE.

A. Inorganic Constituents: Mineral matter (chiefly calcium and phosphorus) which gives the bone strength and rigidity. These non-living constituents comprise about 67 percent of fresh bone.

1. ______________________bone: This is the external dense osseous material. Radiologists refer to compact bone as the ___________________________________.

2. ______________________bone: A lattice work of internal osseous material. Spongy appearing, hard bone made up of slender bars called trabeculae.

B. Organic Constituents: The living portion of bone which consists of two types of osteocytes (osteoblasts and osteoclasts) and bone collagen. The living constituents make up about 33 percent of fresh bone and make the bone flexible.

C. The ______________________cavity is the internal cavity of bones that contains the bone marrow. In long and short bones, it is called a canal.

D. Periosteum. Except where joined to articular cartilage, the bone is covered with a fibrous dense connective tissue called __ ____________ _______________. Blood vessels, nerves, and lymphatic vessels are in the periosteum.

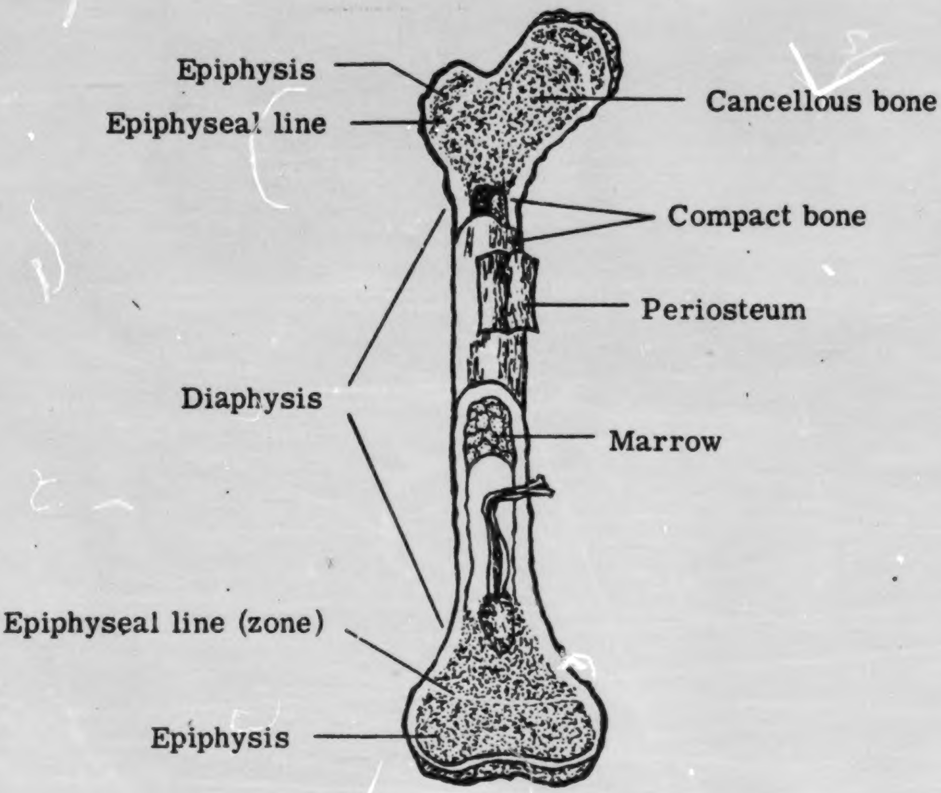
E. Bone Marrow. Bone marrow is situated in the spaces of cancellous (spongy) bone and the medullary cavity.

1. Red marrow (found in all bones of the ________________________, and flat bones and some cancellous bone of the adult) forms red blood cells and some of the white blood cells.

2. Nonfunctional ________________ __________________ is found in medullary canal of adults.

36

Structure of a Long Bone


Epiphysis
Epiphyseal line
Cancellous bone
Compact bone
Periosteum
Diaphysis
Marrow
Epiphyseal line (zone)
Epiphysis

Longitudinal Section of a Long Bone (femur)

F. Endosteum. The ________________________ lines the inner surface of the bone tissue and the outer surface of the medullary cavity.

II. STRUCTURE OF BONE.

A. Shaft or Body: The long cylindrical part of a bone; the principal portion of a bone.

B. Extremity: The expanded end of a bone.

C. Head: The expanded portion at the end of a bone, always

______________________________________.

D. ________________________: The constricted portion next to the head.

E. ________________________: The expanded portion of a bone at opposite end of the head.

F. ________________________: A branch of a bone--a major division.

G. Projections Found on Bones

1. ____________________: A general term for projection.
2. ____________________: A sharp projection.
3. ____________________: A small roughened projection.
4. ____________________: A large eminence, usually roughened, for the attachment of tendons or ligaments.
5. ____________________: A projecting ridge of bone.
6. ____________________: A smooth, rounded swelling at the articular end of a bone.
7. ____________________: A small eminence of bone above the condyle, usually roughened, for the attachment of tendons and ligaments.

H. Depressions Found on Bones

1. ____________________: A pit, or open cavity.
2. ____________________ or ____________________: A smooth depression on the surface of a bone for articulation with another bone.

3. ____________________ or ____________________: An elongated depression on the surface of a bone; a furrow.

I. Miscellaneous Structures.

1. Fissure: A narrow __________________________ between two bones.

2. _________________________: A relatively crooked canal through or between bones.

3. _________________________: A hole or opening in a bone for passage of blood vessels or nerves.

4. Sinus or antrum: Terms used to designate a ______________________

_____________________ within a bone.

I. FORMATION AND GROWTH OR BONE.

A. Endochondral: ____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

B. Intramembranous: ______________________________

IV. CLASSIFICATION OF BONES.

A. Long: Long, usually cylindrical, shaft with two expanded extremities.

EXAMPLE: ______________________________

B. Short: Short, usually cylindrical, shaft with two expanded extremities.

EXAMPLE: ______________________________

C. Flat: Two plates of hard, bony substance with a thin layer of spongy marrow in between.

EXAMPLE: ______________________________

D. Irregular: Bones whose size and shape are modified by their function and position.

EXAMPLE: ______________________________

E. Sesamoid: Small bones embedded in tendons which pass over the joints. In addition to diminishing friction, they modify pressure and help to protect ligaments and tendons.

EXAMPLE: ____

F. Supernumerary Bones: Bones occurring in numbers greater than normal.

V. FRACTURES

A. A fracture is the breaking of any part, especially of a bone.

The abbreviation for fracture is ____________________. Fractures are generally classified as ____________ or ____________________.

A fracture is __________________ (simple) if the overlying skin is intact. ________________________ or ___________________ refers to a fracture in which there is an external wound leading to the break of the bone.

B. Fractures are further classified by position, number of fragments, and direction of fracture line as follows:

1. ______________________: Usually a straight-line break at right angles to the long axis of the bone.
2. ______________________: The fracture line is s-shaped.
3. ______________________: The fracture line roughly parallels the long axis of the bone.
4. ______________________: The break extends diagonally to the long axis of the bone.
5. ______________________: The broken ends, or fragments, are jammed firmly together.
6. ______________________: One side of the bones is broken, the other side is bent.
7. ______________________: The bone is crushed or splintered into three or more fragments.

8. Stellate fracture: ______________________________

____

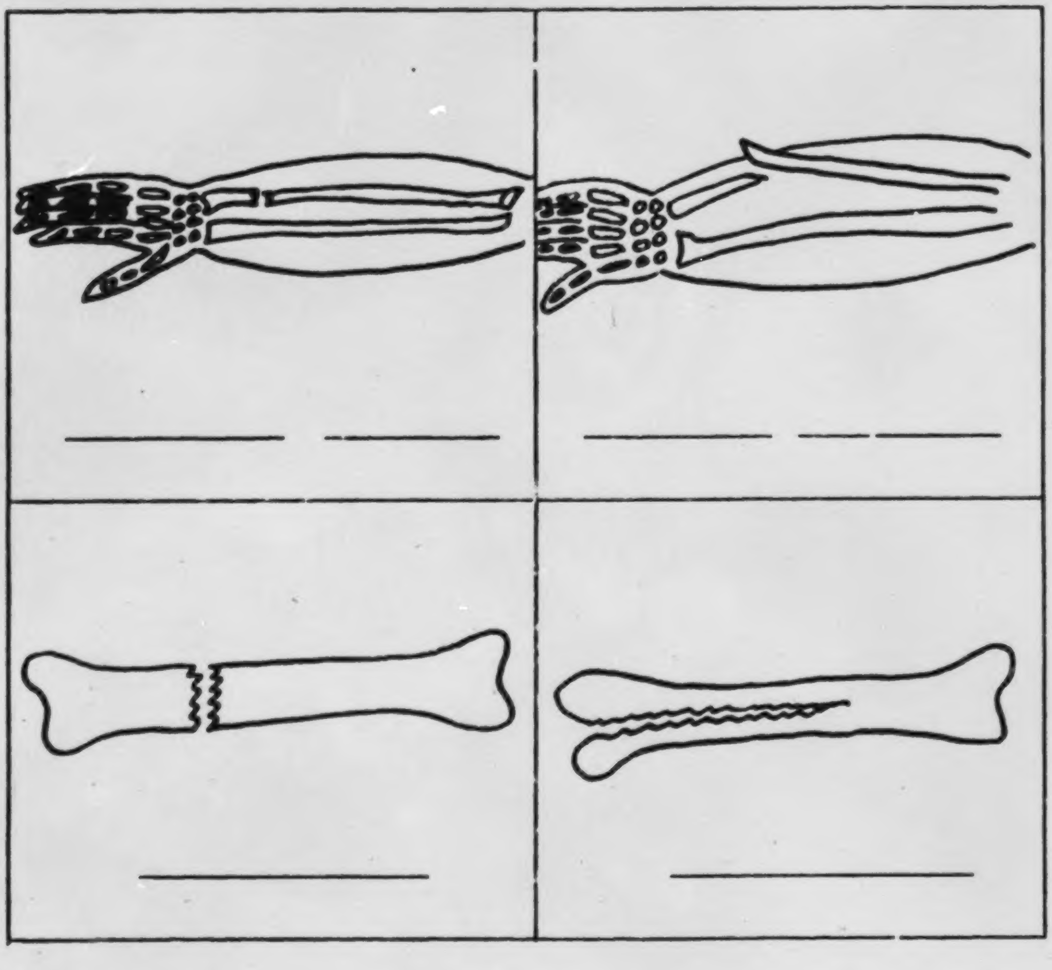
9. Buttonhole fracture: ____________________________

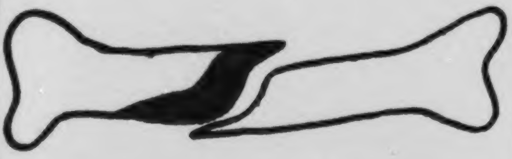
____

10. Compression fracture: __________________________

____

FRACTURE TYPES





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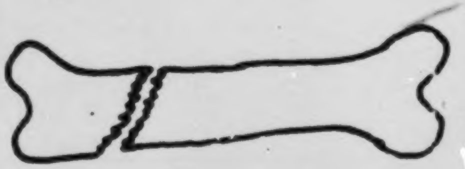

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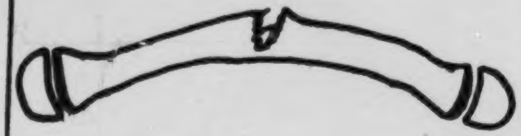

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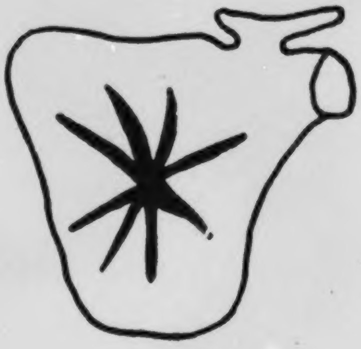

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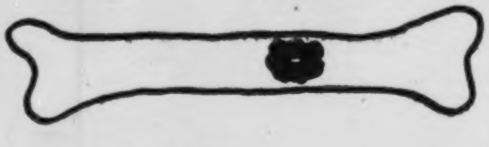

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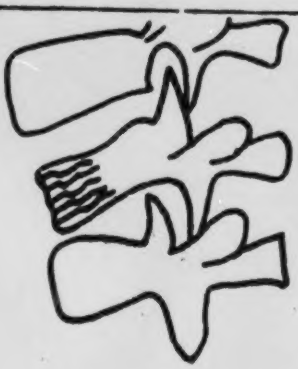

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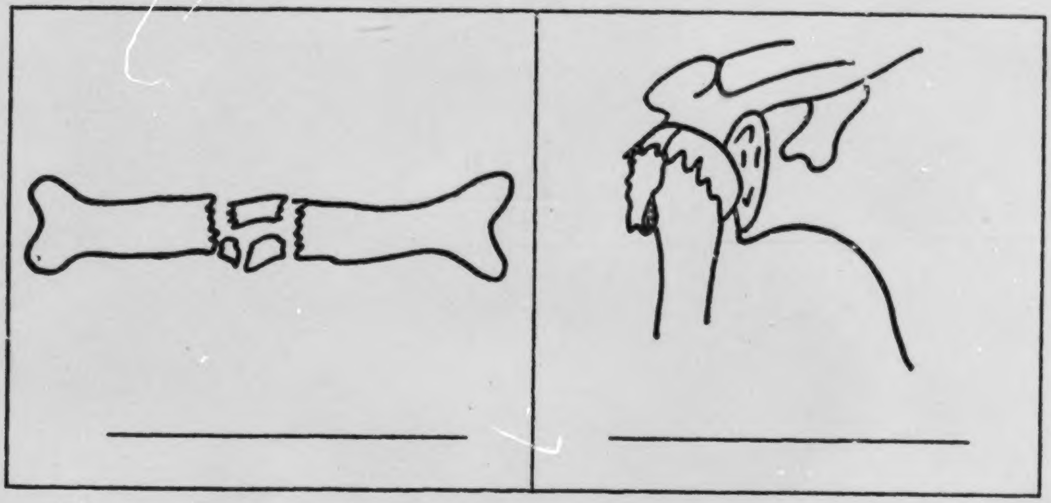


44

GENERAL ARTHROLOGY

Objectives

1. List and define the structures of a joint.
2. Define joint classifications and movements.

I. JOINT STRUCTURES.

A. ____________________. A dense white mass of connective tissue (elastic) attached to the articular end of bone, commonly called gristle.

B. ____________________. A dense white band of connective tissue that attaches bone to bone.

C. ____________________. The space between the bones, lined by the synovial membrane, and filled with synovia.

D. ____________________. The viscous fluid of a joint cavity.

E. ____________________. A sac filled with fluid (synovia) situated in the tissues at which friction would otherwise develop.

F. ____________________. A dense white cord of connective tissue that attaches muscle to bone.

II. THREE GENERAL TYPES OF JOINTS.

A. __________________________: Immovable type (sutures of the skull).

B. __________________________: Slightly movable (symphysis pubis).

III. MOVEMENTS:

A. Flexion: ______________________________.

B. Extension: ______________________________.

C. Abduction: ______________________________

______________________________.

D. Adduction: ______________________________

______________________________.

E. Pronation: ______________________________.

F. Supination: ______________________________.

G. Inversion: ______________________________

______________________________.

H. Eversion: ______________________________.

I. Rotation: ______________________________.

J. Circumduction: ______________________________

______________________________.

ANATOMY -- INTRODUCTION AND TERMINOLOGY

Objectives

1. Define various studies of the body to include anatomy, physiology, and pathology.
2. List the major components of a cell.
3. Briefly describe the process of cell division.
4. Briefly discuss a cell's sensitivity to x-radiation.
5. Using the terms cell, tissue, organ, organ system, and organism, discuss the organization of the body from the simple cell to the complex organism.
6. List the seven main body systems.
7. List the divisions of the skeleton and the regions of the body they comprise.

I. INTRODUCTION

A. ______________________: Systematized and classified knowledge.

B. ______________________: A science or branch of knowledge.

C. Anatomy (Greek--to cut apart): The science of the ____________ ______________________of the body and the spatial relation of its parts.

NOTE: Descriptive or systemic anatomy includes the following subdivisions:

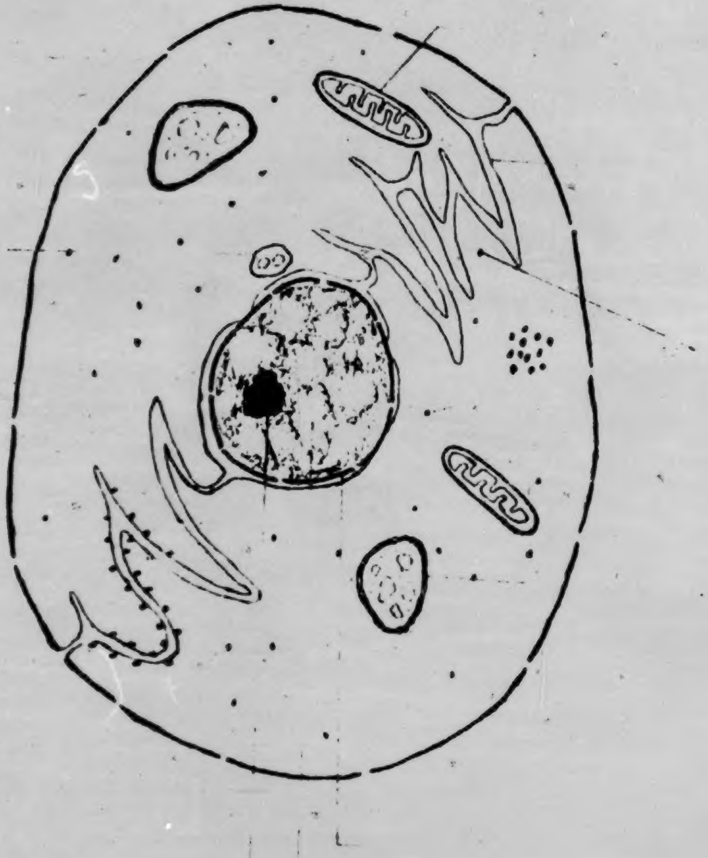
1. _________ __________: The study of the bones.
2. ____________________: The study of the articulations or joints.
3. ____________________: The study of the muscular system.
4. ____________________: The study of the nervous system.
5. ____________________: The study of the blood-vascular system.

D. Physiology: The science which treats the ____________ ____________ of the living organism and its parts.

E. Embroyology: The science that deals with the origin of the structures of the body.

F. Pathology: The science that deals with the ____________________ __________________________of the structure and functions of the body due to disease or injury.

THE CELL



II. THE HUMAN BODY

A. Cell: The structural, functional, and developmental unit of the body.

1. Components of a cell.

a. _________ ___________: The semipermeable molecular layered boundary of a cell that controls the exchange of nutrients and waste between the cell and its environment.

b. ____________: Semiliquid living mass in which the small organs (organelles) are suspended.

1) _______________: "Power House" The respiratory center which produces energy packets the cell utilizes.

2) _____________ _______________: Interconnecting series of canals for transporting substances.

3) ___________: Small granules that synthesize proteins.

4) ___________: Digestive center where large molecules are broken down and aids in destroying the cell after useful life.

5) ___________: Contains the centrioles which form the "rays" of the spindle during cell division.

c. ___________: Control center of the cell.

1) __________ ___________: Semipermeable structure that bounds the nucleus.

2) ___________ ___________: The chromosomes which are thread-like (uncoiled) and composed of genes which consist of deoxyribonucleic acid (DNA) , the molecule of heredity.

3) ___________: Dense rounded body primarily consisting of ribonucleic acid (RNA), which attaches to ribosomes in the cytoplasm and participates in protein synthesis.

d. _____________: Stored nutrients, pigments, and minerals within the cytoplasm.

B. ____________________: An arrangement or organization of cells specialized in the performance of one or more specific functions.

1. Types of tissue.

   a. ____________________.

   b. ____________________.

   c. ____________________.

   d. ____________________.

2. Content of water in tissues.

   a. Muscle: __________ percent.

   b. Nervous: __________ percent.

   c. Bones with marrow: __________ percent.

   d. Fat: ______ to 30 percent.

   The content of water in tissue determines, to a large extent, the amount of secondary radiation emitted from a part.

C. Organ: An organization of tissues arranged in a definite pattern and performing some special function.

D. Organ System: An arrangement of organs concerned with similar or allied functions.

E. Organism: An individual constituted to carry on the activities of life by means of organs separate in function, but mutually dependent.

III. THE ORGAN SYSTEMS.

A. Muscular System: Causes movement by ____________________. makes up approximately 50 percent of the total weight of the body.

B. ____________________ System: Concerned with the behavior of the individual. Behavior is the adjustment of the individual to external environment and the regulation of the internal organs.

50

C. ________________ System: Digests food for its absorption into the bloodstream.

D. ________________ System: Supplies the blood with oxygen from the outside air and eliminates carbon dioxide from the blood to the outside.

E. ________________ System: The organs specialized for secretion and discharge of the urine and the genital organs concerned with the reproduction of the individual.

F. ________________ System: Collects and transports substances such as digested food material, internal secretions, oxygen, carbon dioxide, and liquid waste products of metabolism from one part of the body to another. The lymphatic system assists the blood-vascular system in these processes.

G. ________________ System: The highly specialized group of organs which produce internal secretions called hormones.

H. Skeletal System: A ______________________ system.

1. Functions

   a. Supports the body.

   b. Serves to ________________ the vital organs.

   c. Gives the body definite shape.

   d. Forms a system of ________________ by means of which the muscles attached to the bones execute bodily movements.

   e. Acts as a __________________ for calcium salts.

   f. Is a source of blood cells.

   g. Controls the _______________ pressure of the thoracic cavity by position; therefore, it is a part of the breathing mechanism.

2. Divisions of the skeleton--approximate number--_____ bones

   a. Axial skeleton--(80 bones)

      (1) _____--(__ bones)

         (a) Cranium (brain box)

(b) Facial bones

(2) ____________ column -- (___ bones).

(a) Cervical
(b) Dorsal
(c) Lumbar
(d) Sacrum
(e) Coccyx

(3) ____________ -- (___ bones).

(a) Ribs
(b) Sternum

(4) Bones not listed above -- (7).

(a) Hyoid bone
(b) Auditory ossicles
    Malleus
    Incus
    Stapes

b. The appendicular skeleton -- (126 bones).

(1) __________ ________ -- (___ bones).

(a) Shoulder (pectoral) girdle.
(b) Arms
(c) Forearms
(d) Hands

(2) __________ _________ -- (___ bones).

(a) Pelvic girdle
(b) Thighs
(c) Legs
(d) Feet

__NOTE:__ The sacrum and coccyx comprise a portion of the pelvic girdle but are listed under vertebral column.

NOTE: PAGE 52 HAS BEEN DELETED; HOWEVER ALL MATERIAL HAS BEEN INCLUDED.

OSTEOLOGY OF THE UPPER LIMB

WEEKLY OBJECTIVES AND GOALS
Second Week - Anatomy

By the end of the second week you will be tested on the following objectives. The examination will consist entirely of multiple choice items.

I. Osteology Upper Limb (about 44% of the exam)

A. Select the response which when:

1. Given the name of a bone or bones, states the region (hand, wrist, forearm, arm, and shoulder girdle) in which the bone is located.

2. Given a region in the upper limb, list the bone or bones located in that region.

3. Given a bone, lists the structures located on that bone.

4. Given a list of structures, states on which bone the structures are located.

5. Given a structure, states the bone and the location of that structure (proximal, distal, lateral, medial, anterior and posterior).

6. Given the location of a structure on bone (proximal, distal, lateral, medial, anterior and posterior), identifies that structure.

B. Concerning Bennett's Fracture, Colle's Fracture and the Carrying Angle, select the response that:

1. Defines one of the above.

2. Identifies the correct one, given the definition.

II. Articulations of the Upper Limb (About 10% of the exam)

A. Select the response which when:

1. Given articulated structures that comprise a joint, states which joint is being discussed.

54

2. Given a joint:

   a. Identifies the articulated structures that comprise it.

   b. Lists the movements allowed by that joint.

B. Identify, execute or demonstrate the following movements:

1. Flexion
2. Extension
3. Abduction
4. Adduction
5. Pronation
6. Supination
7. Inversion
8. Eversion
9. Rotation
10. Circumduction

III. Palpation Points of the Upper Limb (about 33% of the exam)

Given a drawing of the upper limb with arrows pointing to several locations on the drawing:

1. Identify the palpation point indicated by a given arrow.

2. Select the correct palpation point as indicated.

IV. Review Questions (about 13% of exam)

Refer to first weeks weekly objectives for review of material.

OSTEOLOGY OF THE UPPER LIMB

I. OUTLINE

  A. Shoulder Girdle (Pectoral Girdle)

    1. Scapula

    2. Clavicle

  B. Arm

    Humerus

  C. Forearm

    1. Radius

    2. Ulna

  D. Hand

    1. Carpals

    2. Metacarpals

    3. Digits

56

Objectives:

1. List and locate, using anatomical references, the bones of the hand.
2. List, describe, and identify the structures found on the hamate, metacarpals, and phalanges.
3. State location of listed structures using: proximal, distal, lateral, medial, anterior and posterior.
4. Describe "Bennett's Fracture"

II. OSTEOLOGY OF THE HAND (Manus)

A. Carpal Region

1. Irregular bones (8)

2. Proximal row

3. Distal

B. Hand Proper--Metacarpals

67

C. Digits (Fingers)

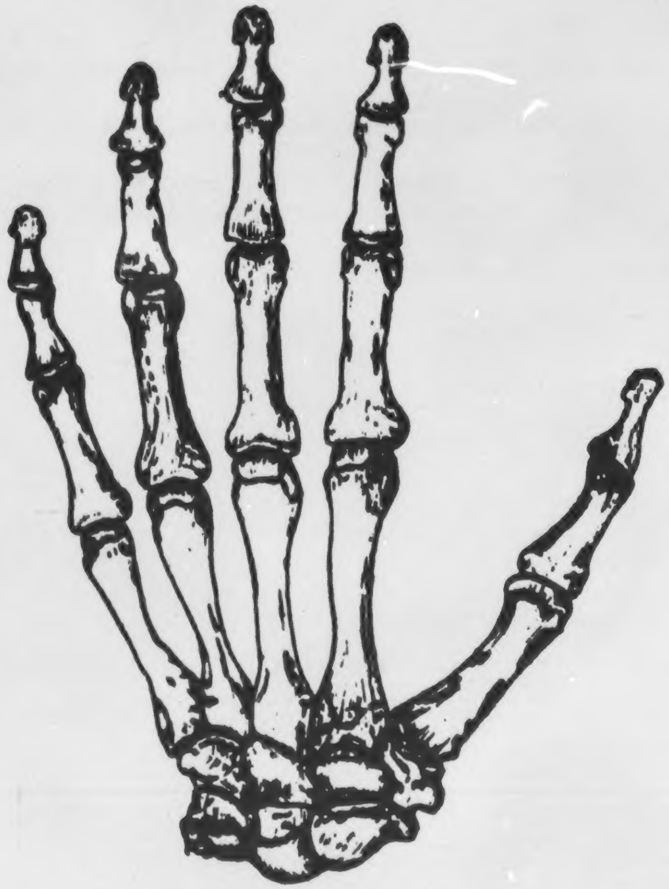
1. 14 phalanges (short bones)
2. Structure
3. Rows

58

Bennett's Fracture

69

Hand - Dorsal Aspect



HAND
(Dorsal Aspect)

Objectives:

1. List and locate, using anatomical references, the bones of the forearm.
2. List, describe, and locate the structures found on the radius and ulna.
3. State the location of listed structures using: proximal, distal, lateral, medial, anterior and posterior.
4. Describe Colle's Fracture.

III. OSTEOLOGY OF THE FOREARM

A. Radius

1. Long Bone
2. Structure
    a. Proximal Extremity

    b. Shaft

    c. Distal Extremity

B. Ulna

1. Long Bone

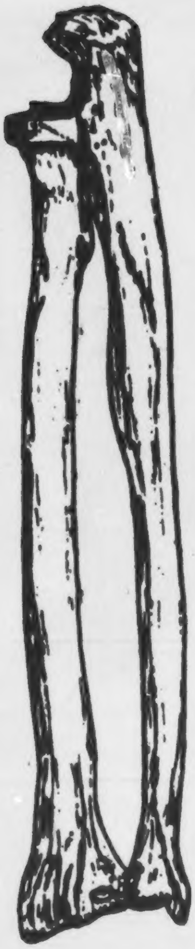
2. Structure

   a. Proximal Extremity

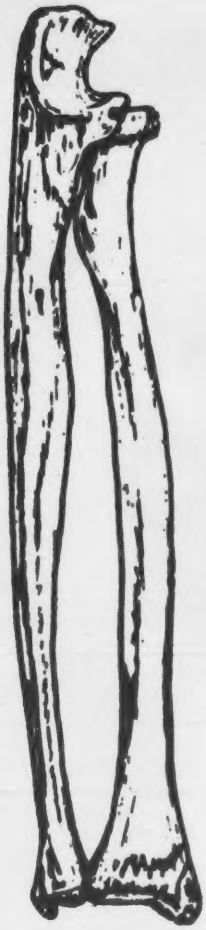
   b. Shaft

   c. Distal Extremity

Colle's Fracture



LEFT ULNA & RADIUS
(Posterolateral Aspect)



LEFT ULNA & RADIUS
(Anteromedial Aspect)

Objectives:

1. Using anatomical references, state the location of the humerus.
2. List, describe and identify the structures found on the humerus.
3. State the location of the listed structures using: proximal, distal, lateral, medial, anterior and posterior.

IV. OSTEOLOGY OF THE ARM

THE HUMERUS

A. Long Bone

B. Structure

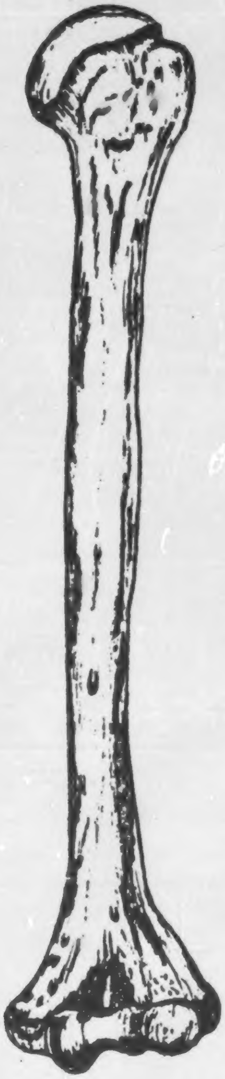
   1. Proximal Extremity

   2. Shaft

   3. Distal Extremity

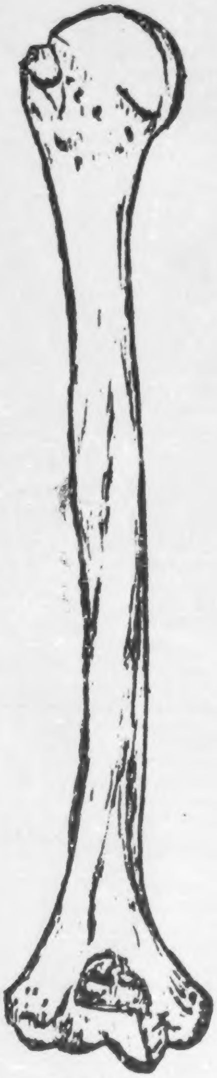
64

Left Humerus



LEFT HUMERUS
(Ventral Aspect)

65



LEFT HUMERUS
(Dorsal Aspect)

Objectives:

1. List and locate, using anatomical references, the bones of the shoulder girdle.
2. List, describe, and identify the structures found on scapula and clavicle.
3. State the location of the listed structures using: superior, inferior, lateral, medial, anterior and posterior.

V. OSTEOLOGY OF THE SHOULDER GIRDLE

A. Incomplete Girdle

B. Scapula

1. Angles

2. Borders

3. Surfaces

4. Spine

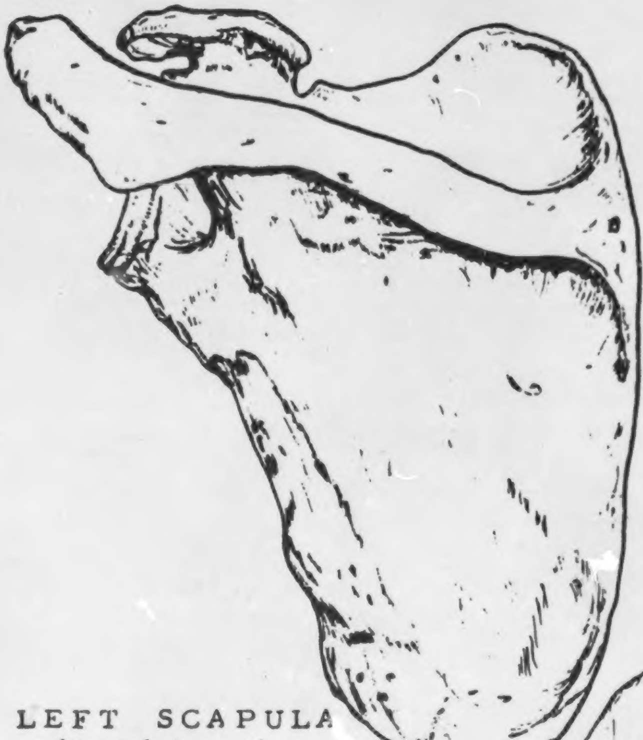
C. Clavicle

1. Acrominal

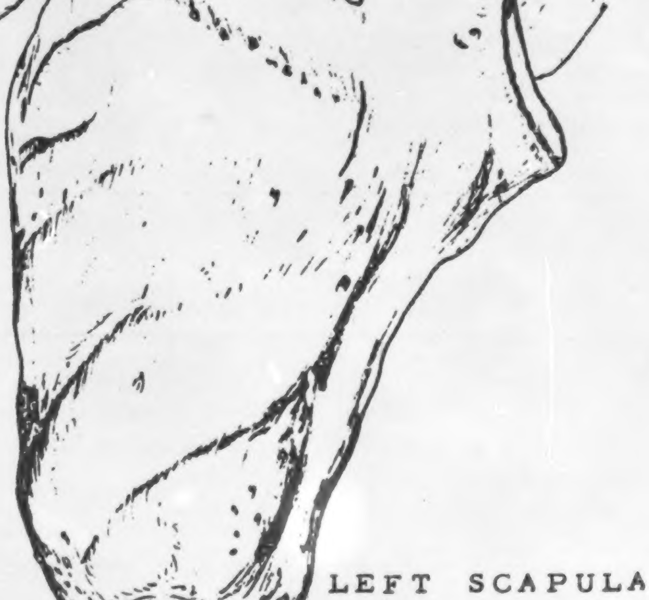
2. Sternal

3. Shaft

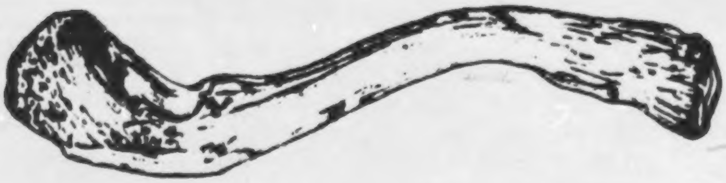
68



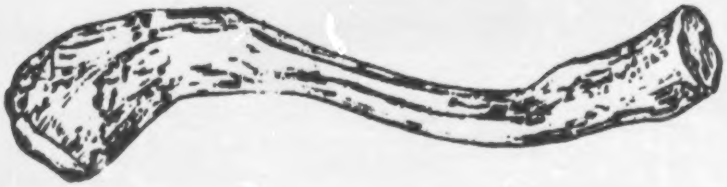
LEFT SCAPULA
(Dorsal Aspect)



LEFT SCAPULA
(Ventral Aspect)



LEFT CLAVICLE
(Superior Aspect)



LEFT CLAVICLE
(Interior Aspect)

ARTICULATIONS OF THE UPPER LIMB

Objectives:

1. Discuss and correlate on radiographs the arthrology of the upper limb.
2. State the normal movements associated with the joints discussed.
3. List the structures which comprise each joint, when applicable.

I. SHOULDER GIRDLE

A. Sternoclavicular. The sternoclavicular is a gliding joint. The sternal end of the clavicle articulates with the clavicular notch of the sternum and with the cartilage of the first rib. An articular disk of fibrocartilage is interposed between the clavicle and the sternum.

B. Acromioclavicular. The acromioclavicular is a gliding joint between the acromial end of the clavicle and the medial edge of the acromion process of the scapula.

C. Movements of the shoulder girdle. The movements of the clavicle at the sternoclavicular joint are those of elevation, depression, protraction (foreward), retraction (backward), and circumduction. The movements of the scapula at the acromioclavicular joint are those of gliding and rotation.

II. UPPER FREE LIMBS

A. Shoulder. The shoulder is a ball-and-socket joint between the head of the humerus and the glenoid cavity of the scapula. A fibrocartilaginous lip (glenoid labrum) deepens the fossa. The movements allowed by the shoulder include flexion (swinging forward), extension, abduction, adduction, circumduction, and rotation.

B. Elbow. The elbow is a hinge joint. The semilunar (trochlear) notch of the ulna articulates with the trochlea of the humerus; and the fovea capitis of the radius articulates with the capitulum of the humerus. The movements permitted by the elbow are those of flexion and extension.

C. Proximal Radioulnar. The proximal radiolunar is a pivot joint. The circumference of the head of the radius articulates with the radial notch of the ulna. The movements include pronation and supination.

D. Distal Radioulnar. The distal radiolunar is a pivot joint between the head of the ulna articulating with the ulnar notch of the radius. The movements of the distal radiolunar are pronation and supination.

E. Wrist. The wrist is a condyloid joint. The navicular and lunate facets on the distal end of the radius articulate with the navicular, lunate, and triangular bones. The movements allowed by the wrist are flexion, extensio abduction, adduction, and circumduction.

III. HAND

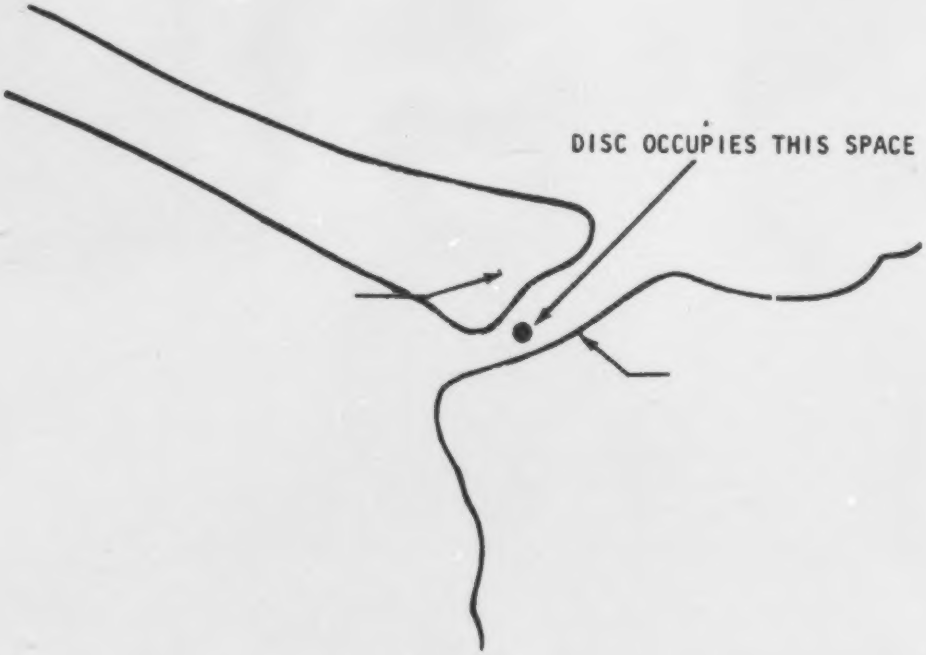
A. Intercarpal. These are gliding joints between the individual carpal bones. Very limited gliding movement is permitted at these joints.

B. Carpometacarpal. The bases of the metacarpals are attached to the distal row of carpals. The greater multangular, attached to the first metacarpal, is a special joint (saddle) which gives man an opposable thumb. The movements allowed by this joint are flexion, extension, abduction, adduction, circumduction. The joints between the carpus and the second, third, fourth, and fifth metacarpal bones are gliding, and their movements are limited to slight flexion and extension.

C. Intermetacarpal. The bases of the second, third, fourth, and fifth metacarpal bones are connected with one another. The intermetacarpal joints are gliding and permit only a slight gliding movement.

D. Metacarpophalangeal. The heads of the metacarpals are joined to the proximal row of phalanges. They are condyloid joints. The movements allowed are flexion, extension, abduction, adduction, and circumduction.

E. Interphalangeal. The joints between the phalanges are the interphalangeal. They are hinge-type joints, and the movements of the phalanges are flexion and extension.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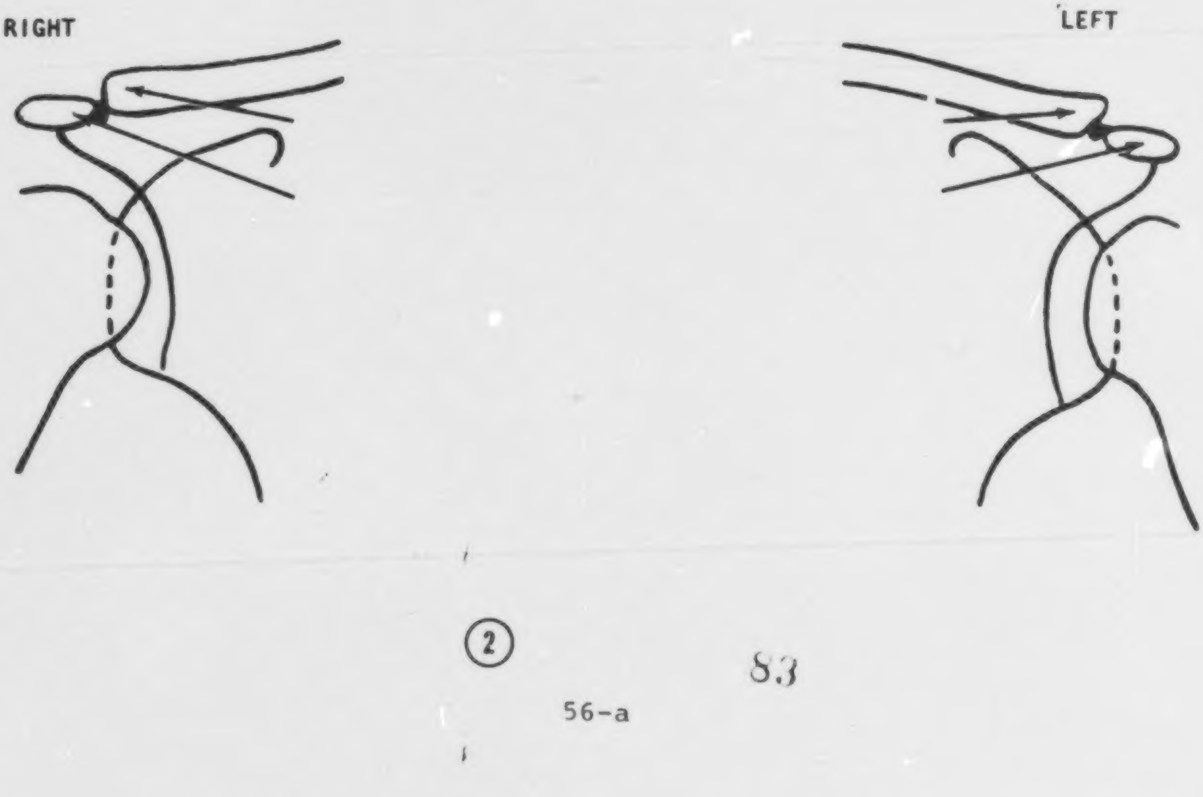
① STERNOCLAVICULAR JOINT ●



②

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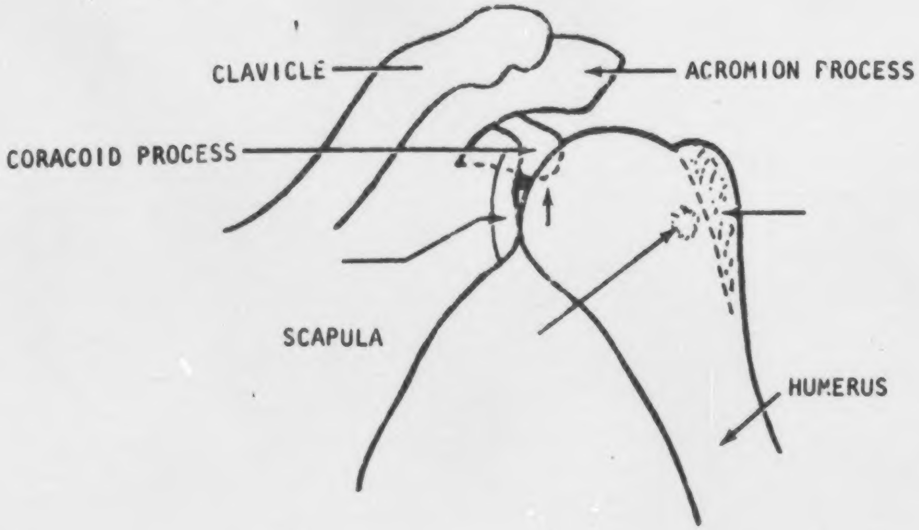
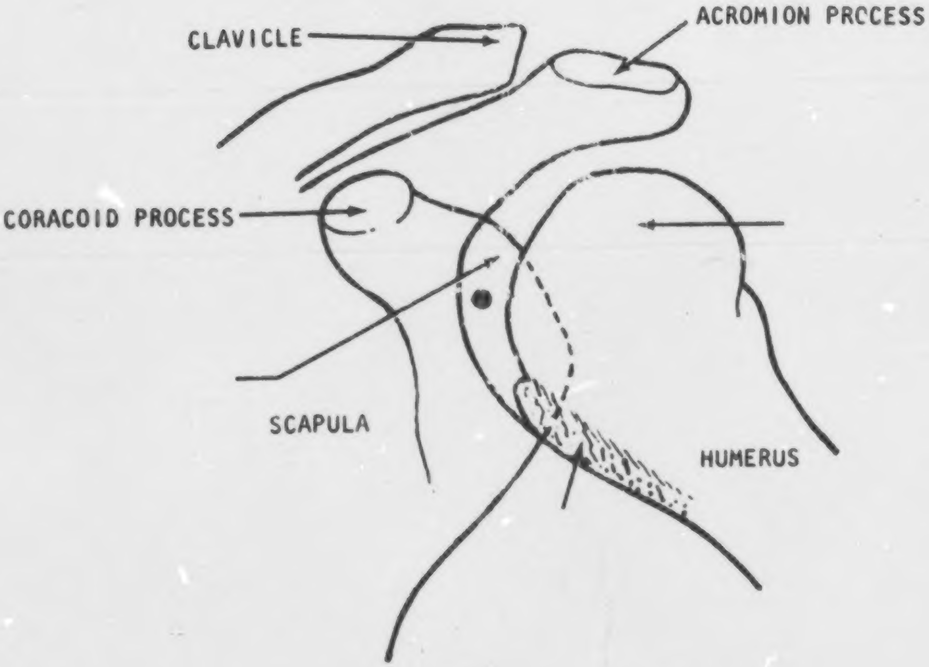
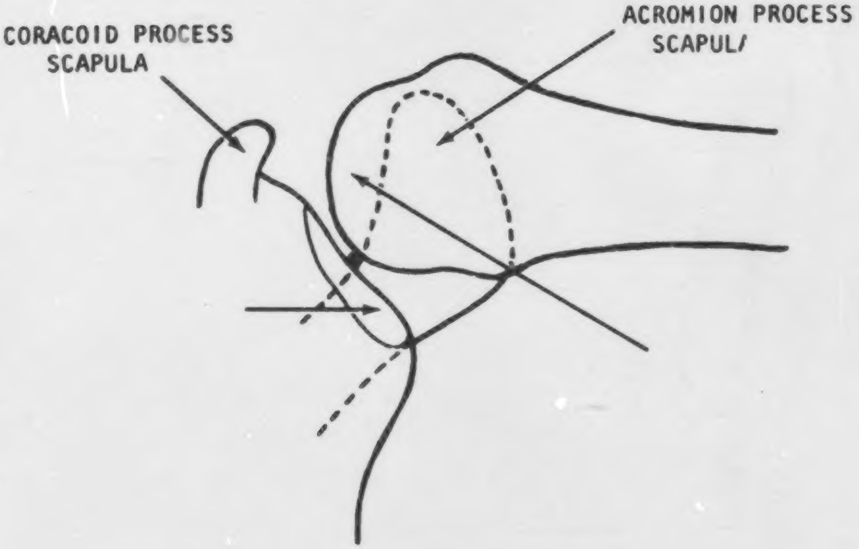

CLAVICLE
ACROMION PROCESS
CORACOID PROCESS
SCAPULA
HUMERUS

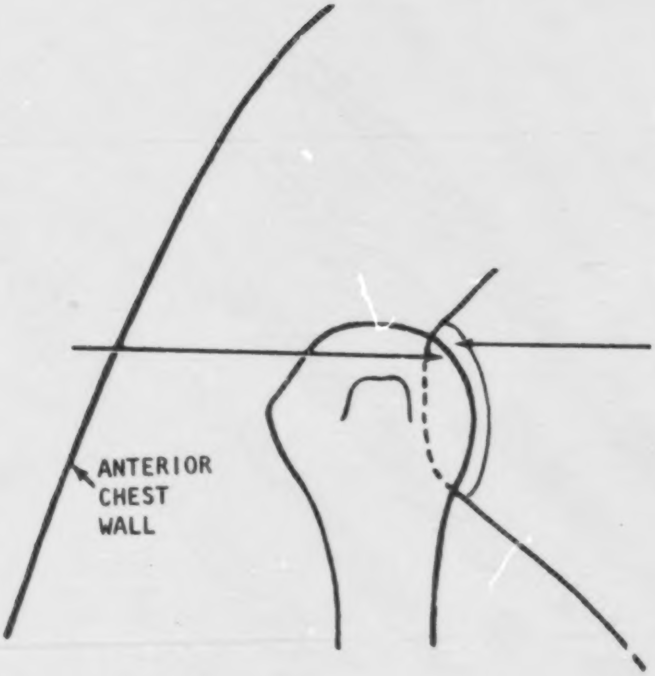
③ SHOULDER JOINT●
(EXTERNAL ROTATION)


CLAVICLE
ACROMION PROCESS
CORACOID PROCESS
SCAPULA
HUMERUS

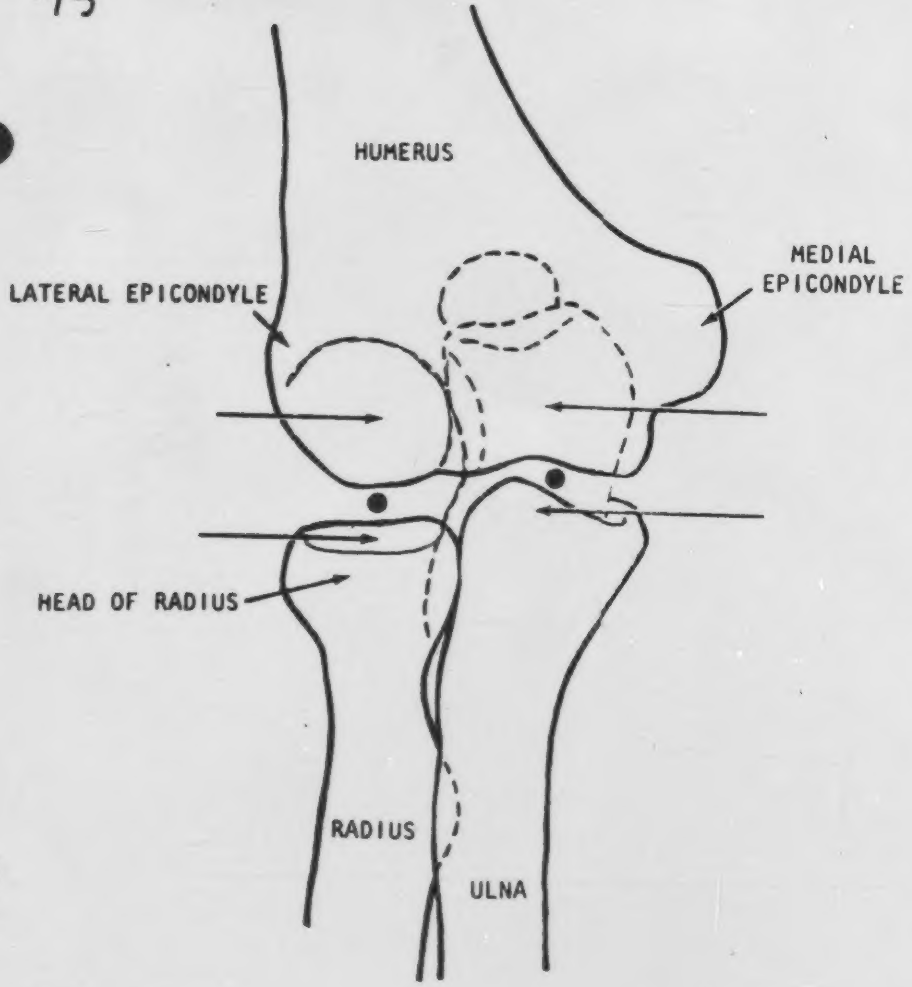
④ SHOULDER JOINT●
(INTERNAL ROTATION)


CORACOID PROCESS
SCAPULA
ACROMION PROCESS
SCAPUL/

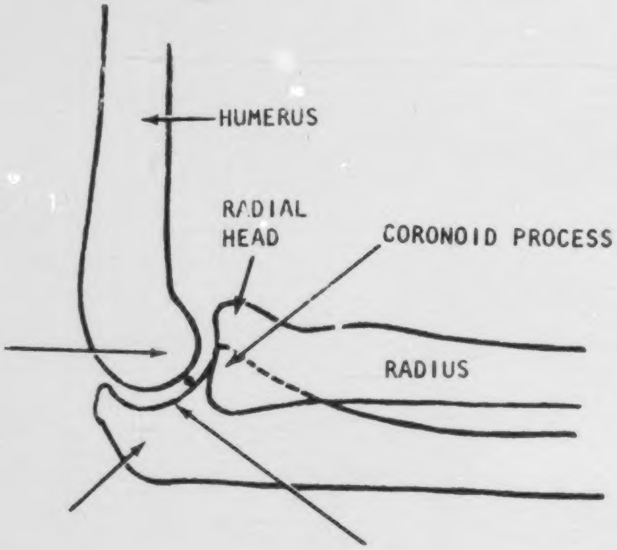
⑤ THE SHOULDER JOINT
(INFERIOR-SUPERIOR VIEW)


ANTERIOR
CHEST
WALL

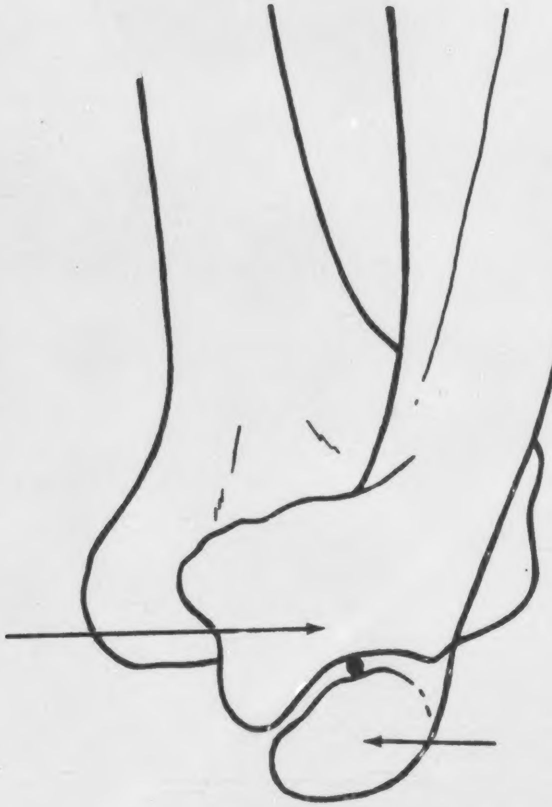
⑥ TRANSTHORACIC VIEW
OF HEAD AND NECK OF
THE HUMERUS


HUMERUS
MEDIAL EPICONDYLE
LATERAL EPICONDYLE
HEAD OF RADIUS
RADIUS
ULNA

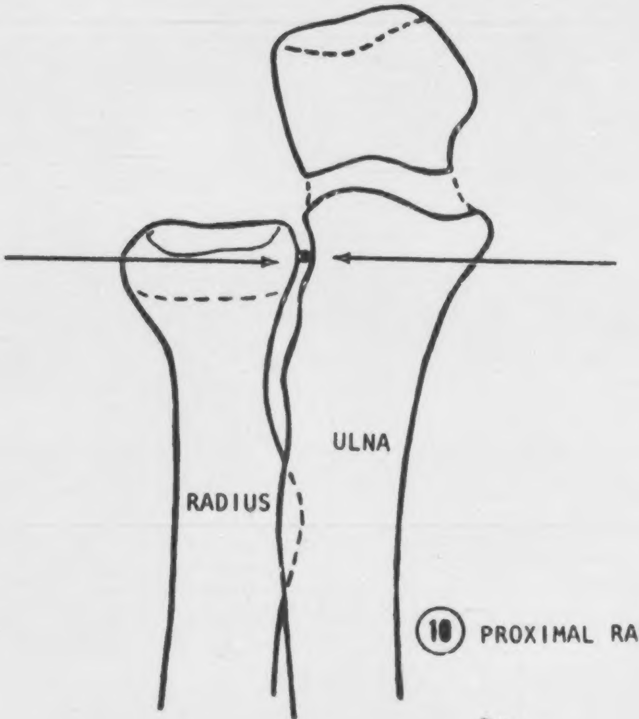
⑦ ELBOW JOINT ●


HUMERUS
RADIAL HEAD
CORONOID PROCESS
RADIUS

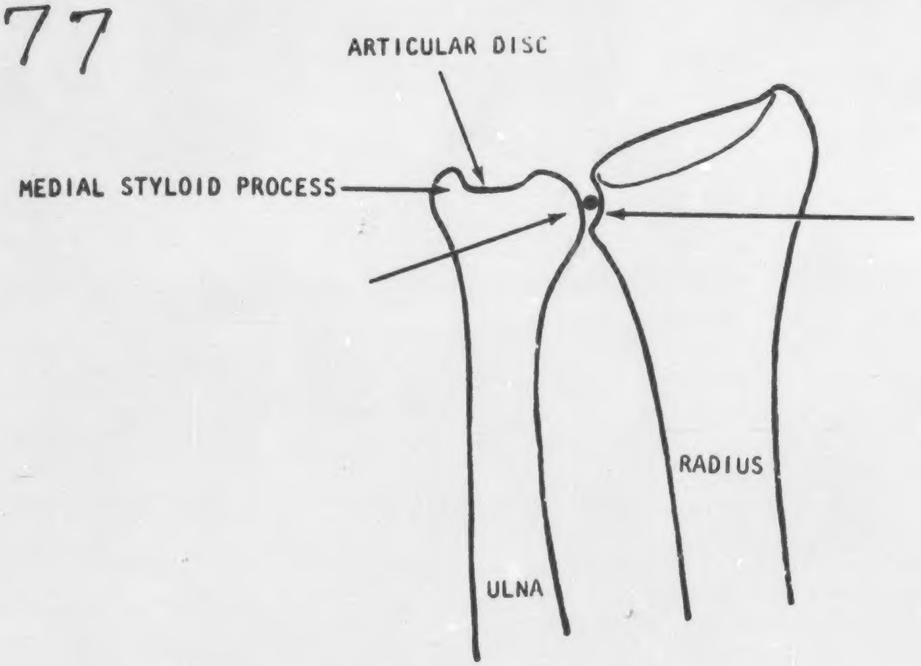
⑧ ELBOW JOINT ●



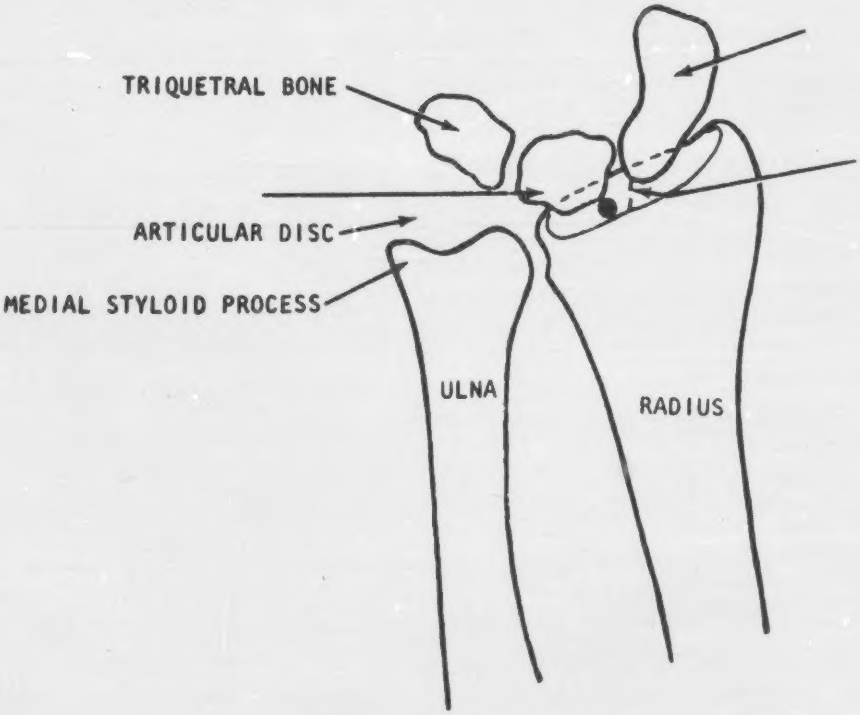
⑨ THE ELBOW JOINT ●
(FULL FLEXION)


ULNA
RADIUS

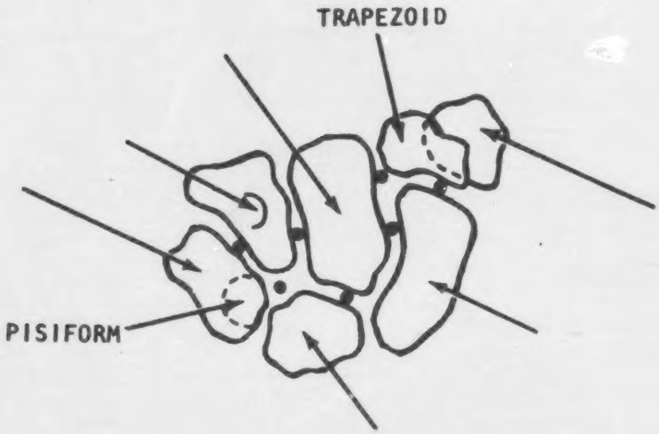
⑩ PROXIMAL RADIOULNAR JOINT ●


ARTICULAR DISC
MEDIAL STYLOID PROCESS
RADIUS
ULNA

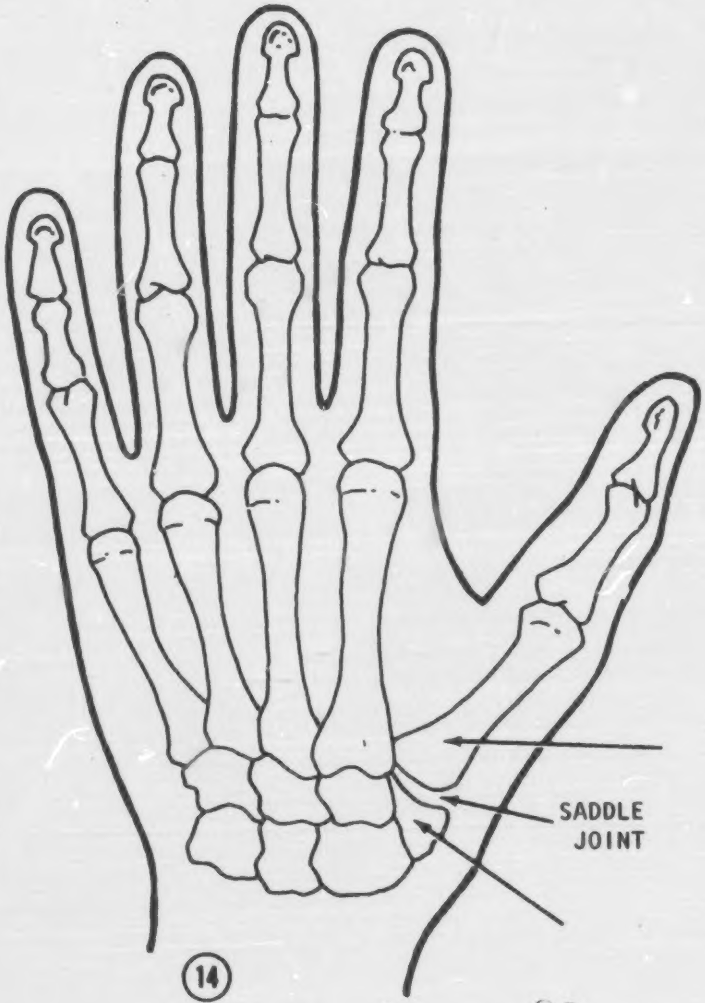
⑪ DISTAL RADIOULNAR JOINT


TRIQUETRAL BONE
ARTICULAR DISC
MEDIAL STYLOID PROCESS
ULNA
RADIUS

⑫

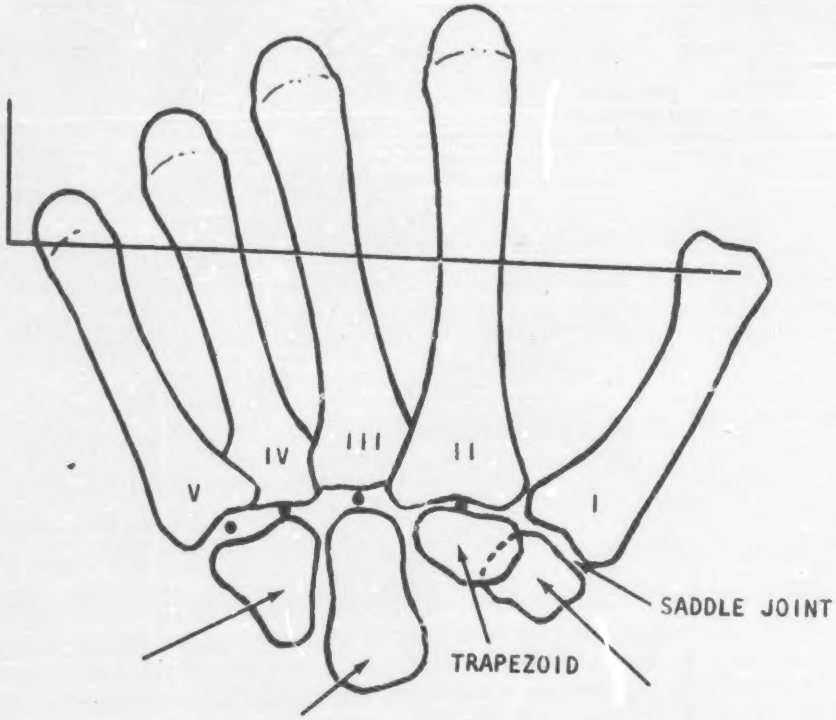

TRAPEZOID
PISIFORM

⑬ INTERCARPAL ARTICULATIONS ●


SADDLE JOINT

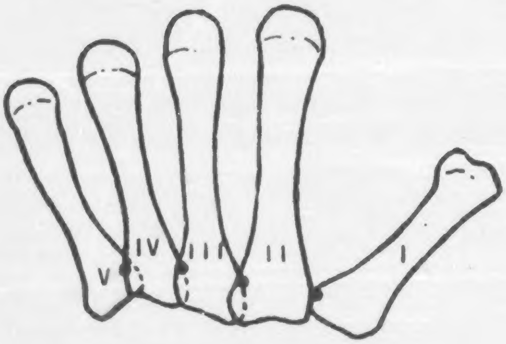
⑭

79



V
IV
III
II
I
SADDLE JOINT
TRAPEZOID

⑮ CARPOMETACARPAL JOINTS



⑯

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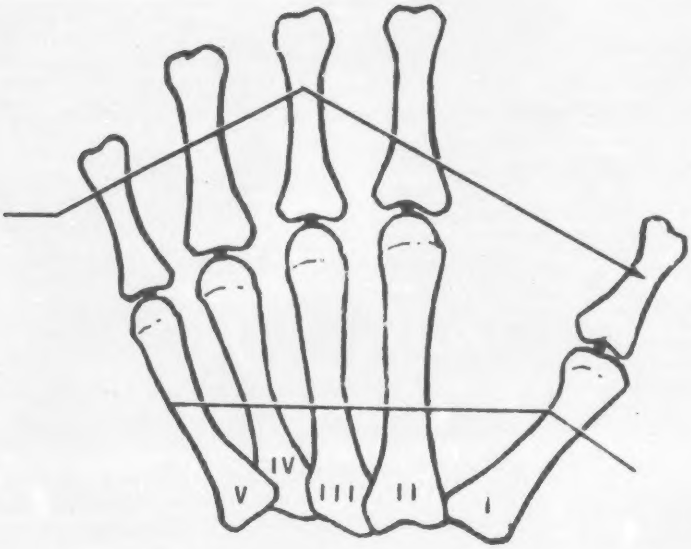
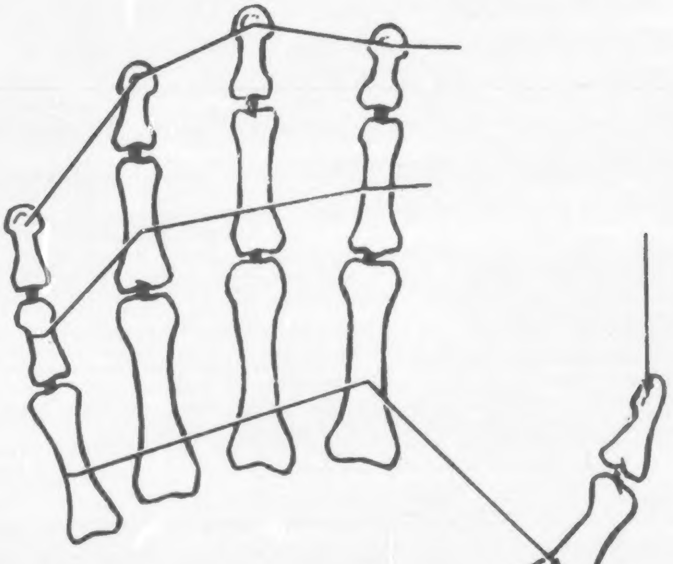


⑰ METACARPALPHALANGEAL JOINTS ●

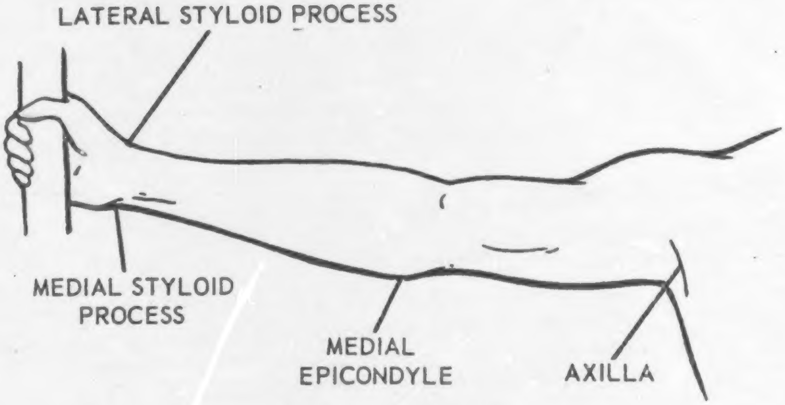


⑱ INTERPHALANGEAL ARTICULATIONS ●

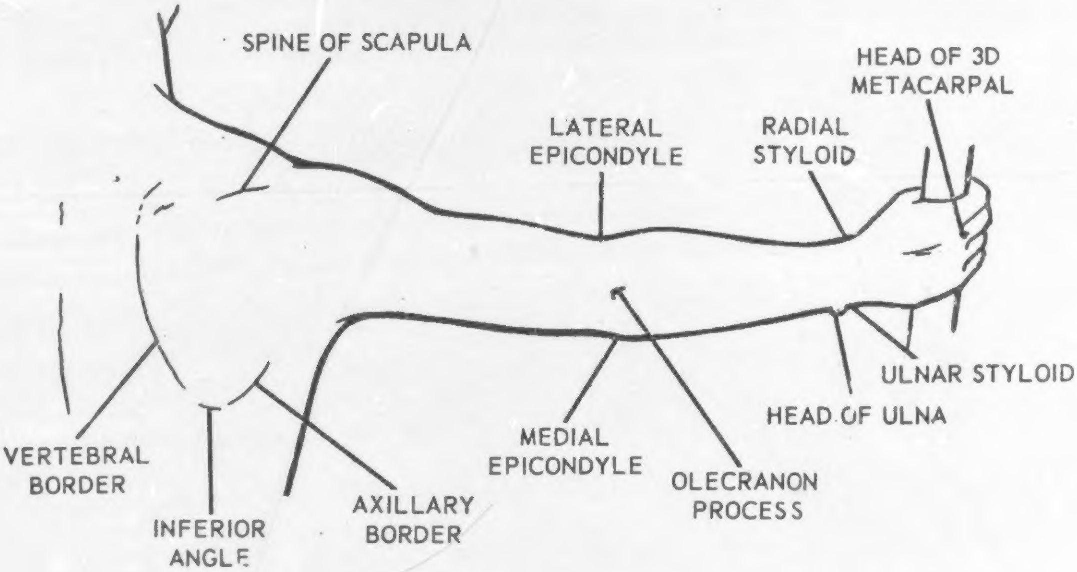
Objectives:

1. List the external landmarks of the upper limb utilized for radiographic positioning.
2. Locate on the line drawing, and the body, the external landmarks of the upper limb.

PALPATION POINTS OF THE UPPER LIMB

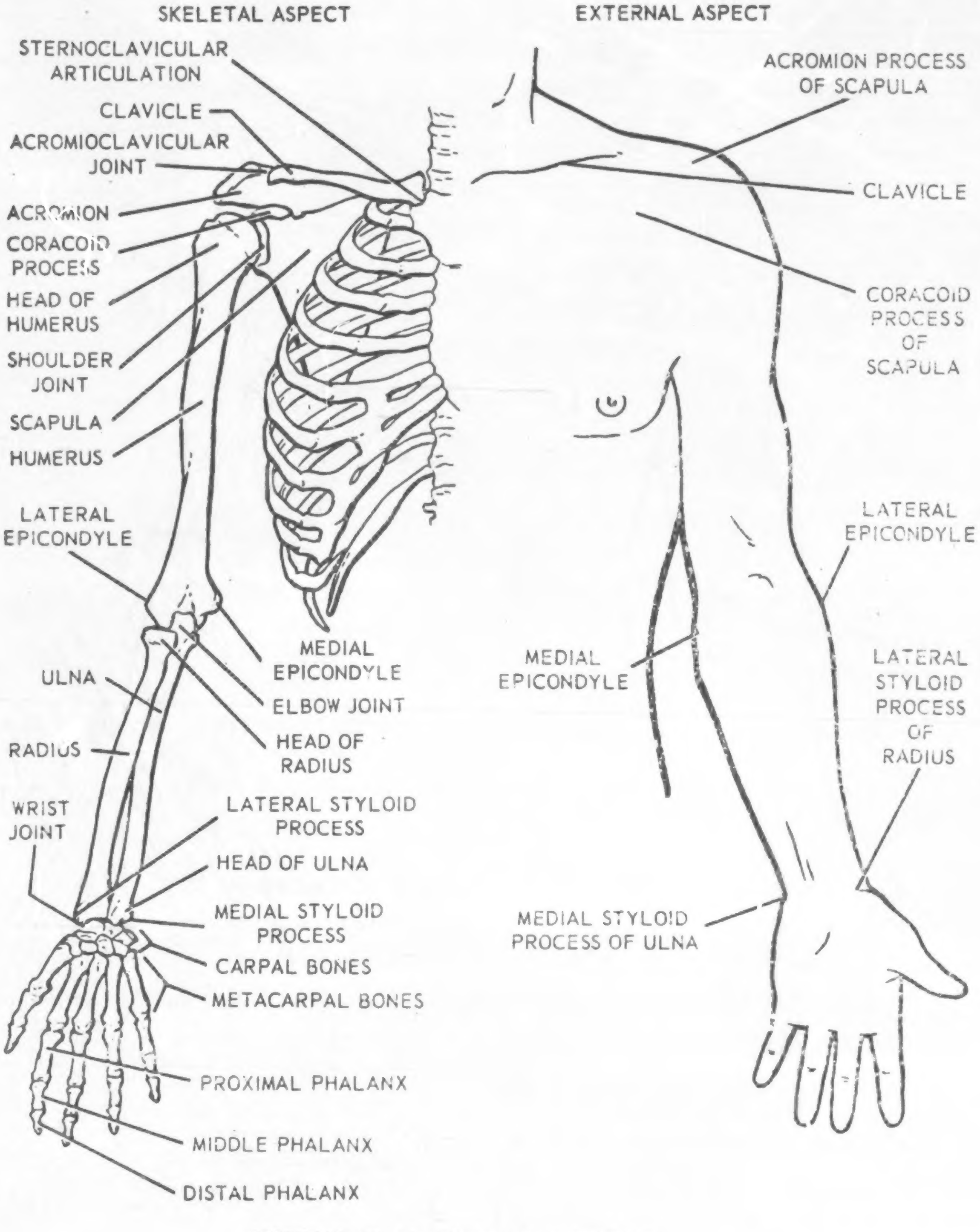

LATERAL STYLOID PROCESS
MEDIAL STYLOID PROCESS
MEDIAL EPICONDYLE
AXILLA

ANTERIOR VIEW


SPINE OF SCAPULA
HEAD OF 3D METACARPAL
LATERAL EPICONDYLE
RADIAL STYLOID
ULNAR STYLOID
HEAD OF ULNA
VERTEBRAL BORDER
MEDIAL EPICONDYLE
OLECRANON PROCESS
INFERIOR ANGLE
AXILLARY BORDER

POSTERIOR VIEW

Palpation Points of the Upper Extremity


SKELETAL ASPECT
EXTERNAL ASPECT
STERNOCLAVICULAR ARTICULATION
CLAVICLE
ACROMIOCLAVICULAR JOINT
ACROMION
CORACOID PROCESS
HEAD OF HUMERUS
SHOULDER JOINT
SCAPULA
HUMERUS
LATERAL EPICONDYLE
MEDIAL EPICONDYLE
ELBOW JOINT
HEAD OF RADIUS
ULNA
RADIUS
WRIST JOINT
LATERAL STYLOID PROCESS
HEAD OF ULNA
MEDIAL STYLOID PROCESS
CARPAL BONES
METACARPAL BONES
PROXIMAL PHALANX
MIDDLE PHALANX
DISTAL PHALANX
ACROMION PROCESS OF SCAPULA
CLAVICLE
CORACOID PROCESS OF SCAPULA
LATERAL EPICONDYLE
MEDIAL EPICONDYLE
LATERAL STYLOID PROCESS OF RADIUS
MEDIAL STYLOID PROCESS OF ULNA

CORRELATION OF BONES AND EXTERNAL LANDMARKS OF THE UPPER LIMB

Radiography Anatomy and Physiology 84

Table of Contents

III Osteology of the Lower Limb

Outline of Lower Limb 61

Osteology of the Foot 62

Osteology of the Leg 67

Osteology of the Thigh 71

Osteology of the Pelvic Girdle 74

Articulations of the Lower Limb 81

Palpation Points of the Lower Limb 83

IV Osteology of the Trunk

Outline of the Axial Skeleton 85

Osteology of the Vertebral Column 87

Osteology of the Thoracic Cage 95

Palpation Points of the Trunk 98

V Internal Anatomy

Urogenital System 100

Respiratory System 111

Nervous System 119

Body Types and Regions of the Abdomen 126

Digestive System 132

Circulatory System 147

VI. Osteology of the Skull

Osteology of the Skull--Cranium 156

Osteology of the Skull--Facial 163

Drawings of the Skull 167

Palpation Points of the Skull 173

Osteology of the Lower Limb

I. OUTLINE

A. Pelvic Girdle or Pelvis (4 bones)

1. _______________bones (2)

2. Sacrum (1)

3. Coccyx (1)

B. Thigh

1. Femur

2. Patella

C. Leg

1. Tibia

2. Fibula

D. Foot

1. Tarsal region--Tarsals

2. Foot proper--Metatarsals

3. Digits--Phalanges

II. OSTEOLOGY OF THE FOOT

A. Tarsal Region

1. Irregular bones

2. Proximal region

3. Distal row

B. Foot Proper

C. Digits

89

D. Terms Dealing with the Foot

1. Arches of the foot

2. Pes Planus

3. Pes Cavus

4. Hallux

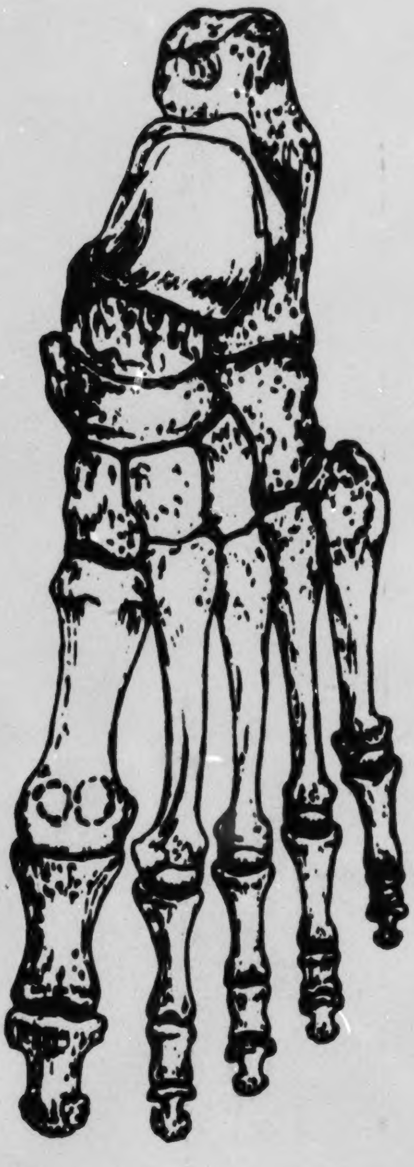
5. Dorsoplantar foot

March Fracture

101

91

Bones of the Left Foot (Dorsal Surface)



BONES OF THE LEFT FOOT
(Dorsal Surface)

III. OSTEOLOGY OF THE LEG

A. Tibia

1. Long bone
2. Structure
   a. Proximal extremity

   b. Shaft

   c. Distal extremity

B. Fibula

1. Long bone

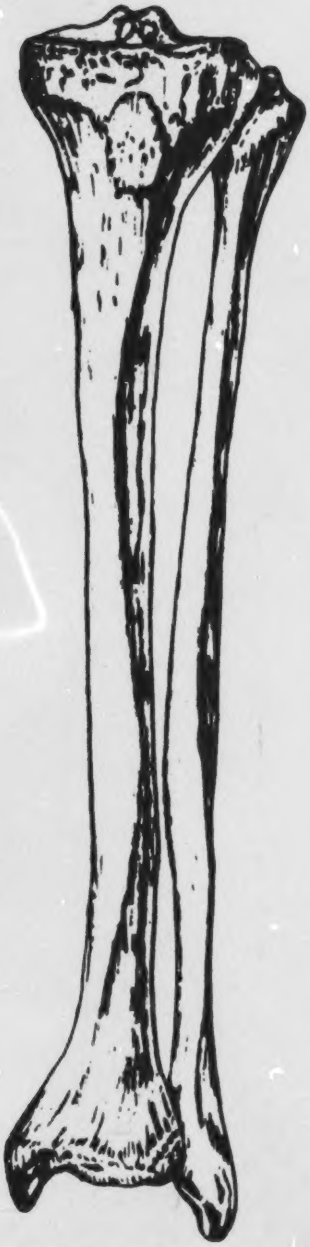
2. Structure

   a. Proximal extremity

   b. Shaft

   c. Distal extremity

Pott's Fracture



LEFT TIBIA AND FIBULA
(Anterior View)

IV. OSTEOLOGY OF THE THIGH

A. The Femur

1. Long bone
2. Structure
    a. Proximal extremity

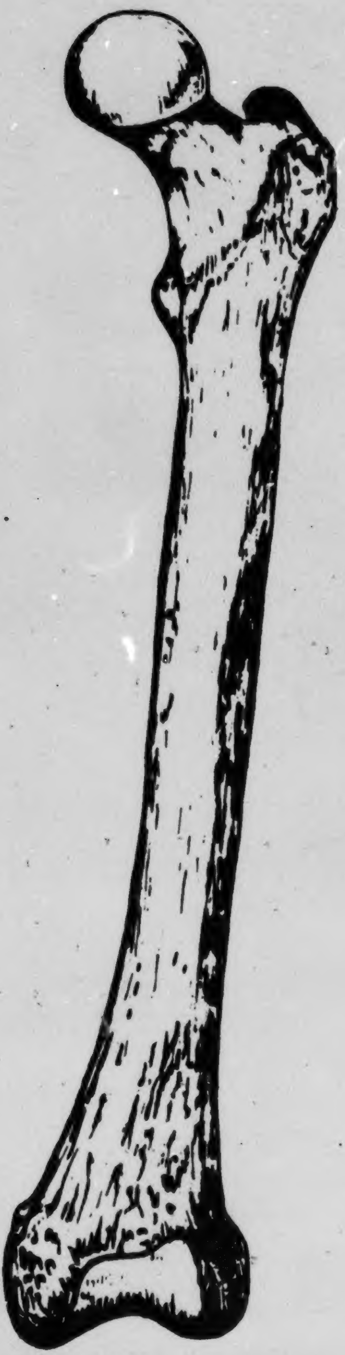
    b. Shaft

c. Distal extremity

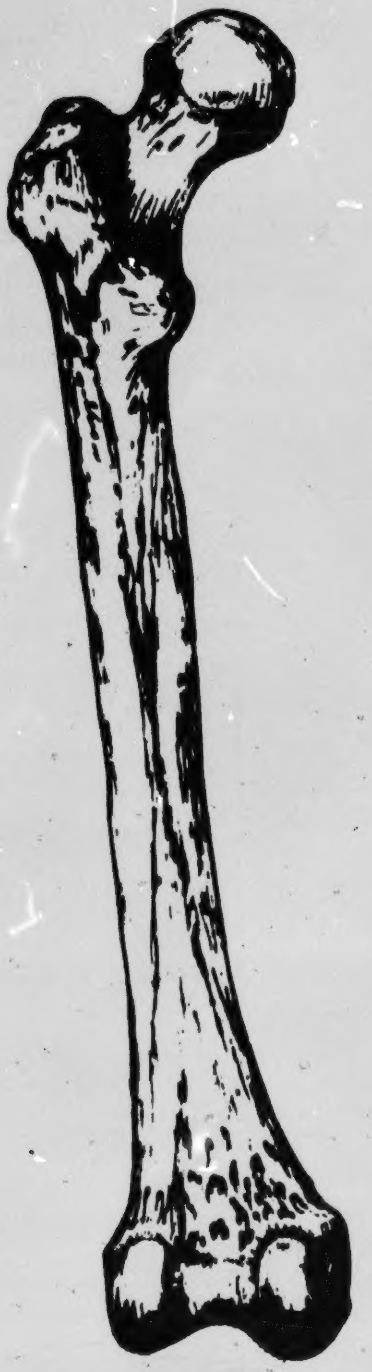
B. The Patella

1. Sesamoid bone
2. Structure

Left Femur

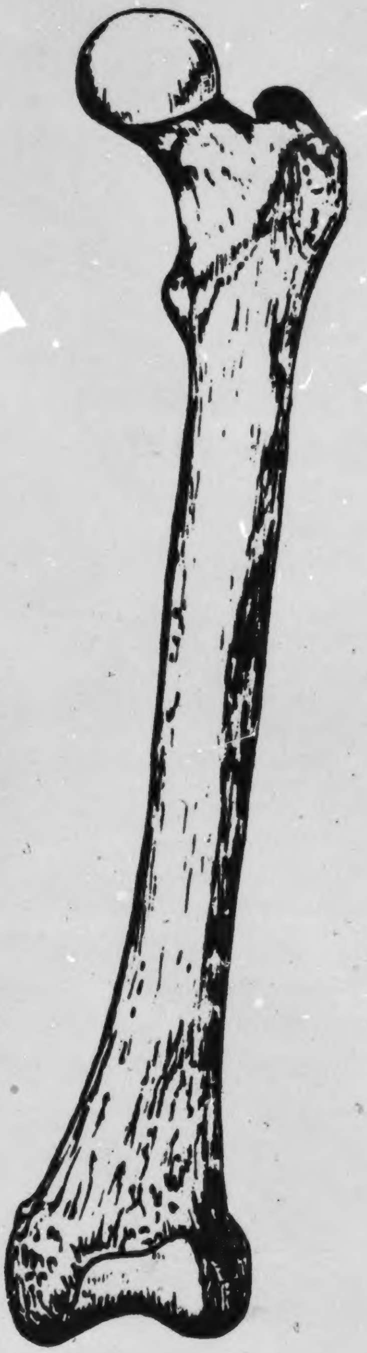


LEFT FEMUR
(Anterior View)

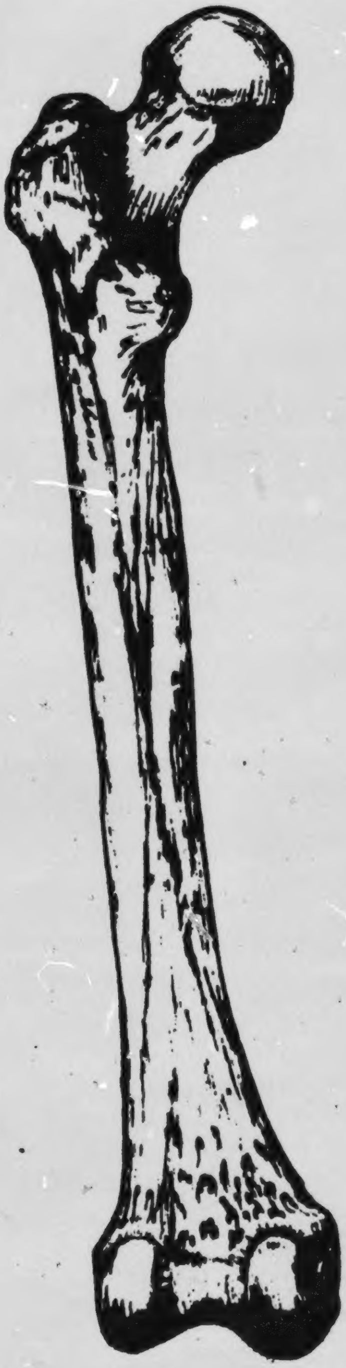


LEFT FEMUR
(Posterior View)

Left Femur



LEFT FEMUR
(Anterior View)



LEFT FEMUR
(Posterior View)

V. OSTEOLOGY OF THE PELVIC GIRDLE

A. Complete Girdle

Composed of: Innominate bones (2)

Sacrum (1)
Coccyx (1) } will be discussed later in conjunction with the vertebral column

B. Innominate bone

1. Flat bone

2. Missing Material

3. Ischium

NOTE: PAGE 100 HAS BEEN DELETED; HOWEVER ALL MATERIAL HAS BEEN INCLUDED.

101

4. Pubis

C. Terms

1. Pelvic ring

2. True pelvis

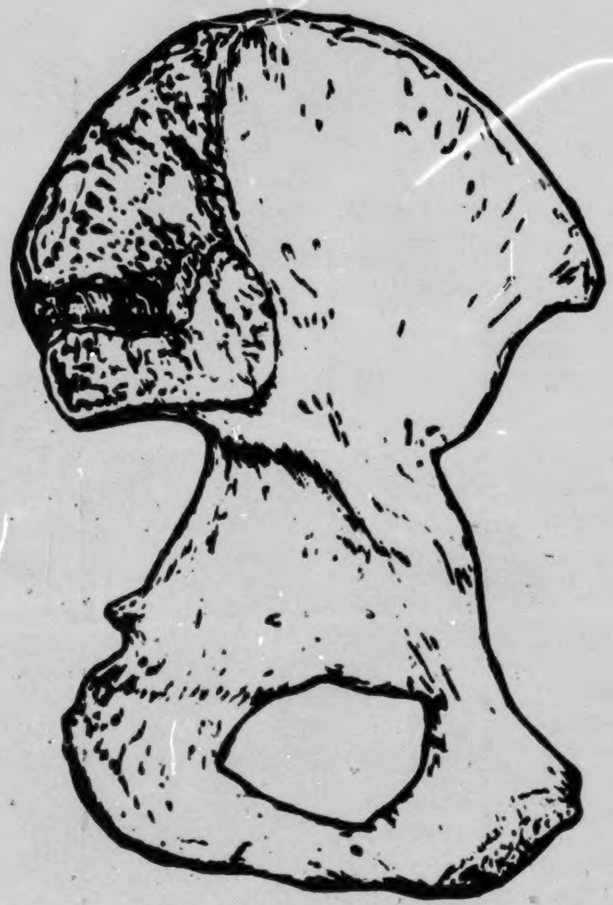
3. False pelvis

4. Sexual differences

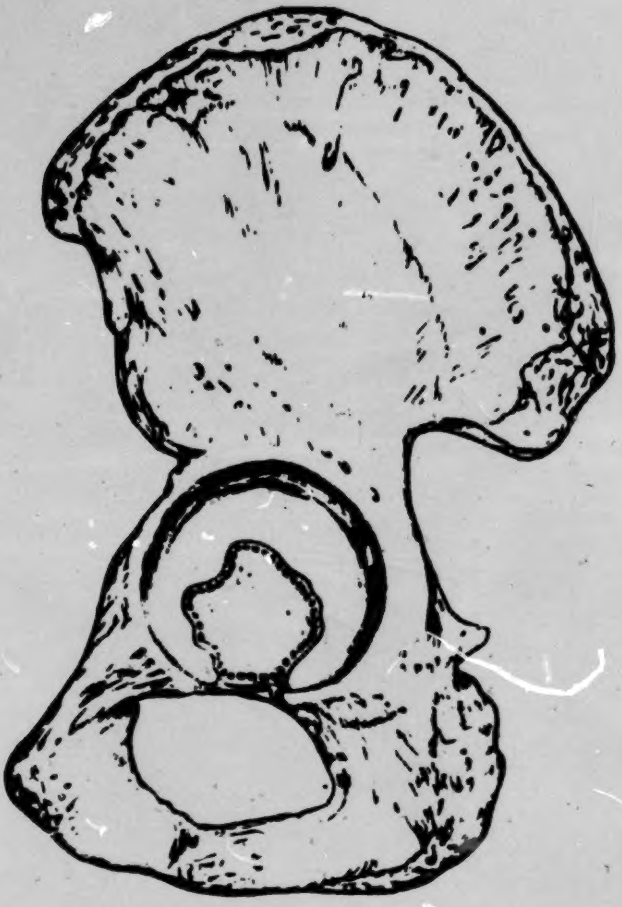
112

5. Pelvimetry

Left Innominate Bone

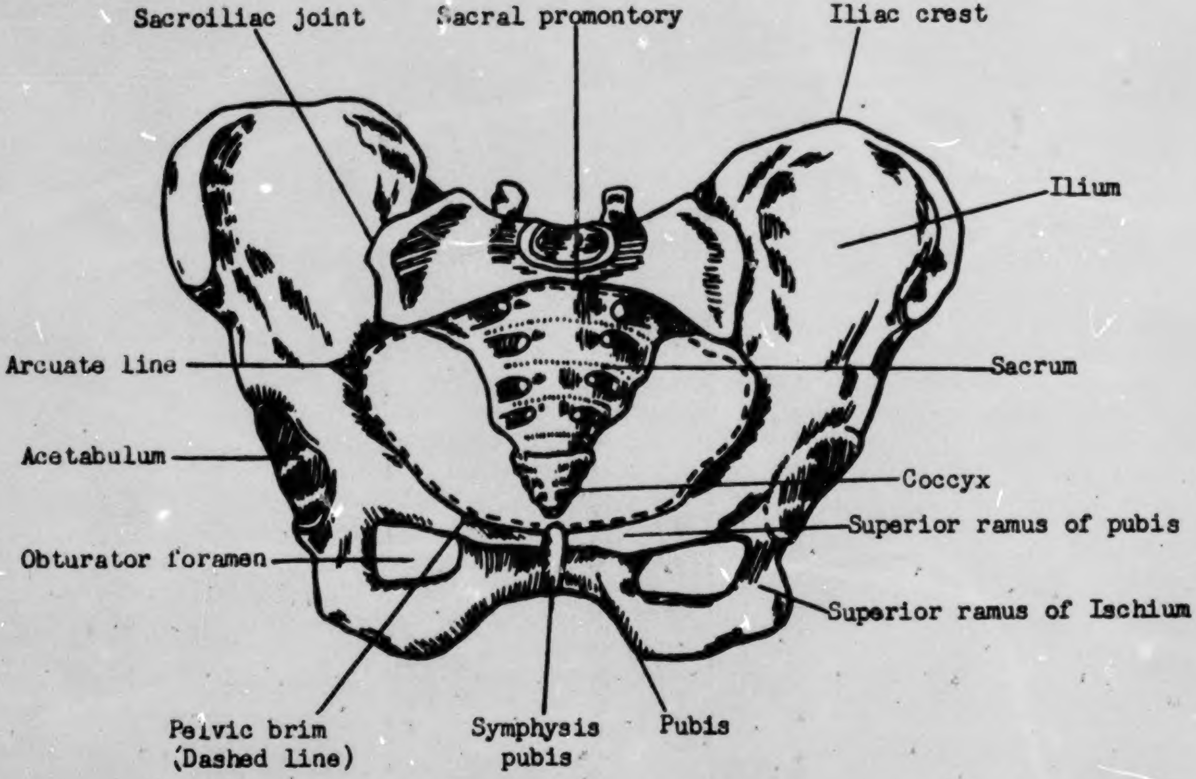


LEFT INNOMINATE BONE
(Medial Aspect)



LEFT INNOMINATE BONE
(Lateral View)

105


Sacroiliac joint
Sacral promontory
Iliac crest
Ilium
Arcuate line
Sacrum
Acetabulum
Coccyx
Superior ramus of pubis
Obturator foramen
Superior ramus of Ischium
Pelvic brim (Dashed line)
Symphysis pubis
Pubis

ANTERIOR VIEW OF THE PELVIS

Articulations of the Lower Limb

Articulations and Movements of the Lower Limb

The study of the articulations and movements or the lower limb are described below:

1. Sacro-iliac. The sacro-iliac joint is formed by the union of the auricular surfaces of the sacrum and the ilium. It is a slightly movable joint.

2. Symphysis Pubis. The symphysis pubis is formed by the junction of the symphysial surfaces of the pubic bones. The pubic fibrocartilaginous lamina is interposed between the symphysial surfaces. It is a slightly movable joint.

3. Hip. The hip is formed by the head of the femur articulating with the acetabulum of the innominate bone. It is a ball-and-socket joint. The movements permitted by the hip include flexion (swinging forward),extension, abduction, adduction, rotation, and circumduction.

4. Knee. The knee may be considered as consisting of three joints in one:

   a. Two condyloid articulations between the lateral and medial condyles of the femur articulating with the corresponding articular facets of the condyles of the tibia. The movements are flexion and extension, hinge type.

   b. The patellofemoral articulation between the posterior surface of the patella and the patellar facet of the femur. This joint is best described as gliding; the movement, gliding.

5. Superior Tibiofibular. This is the joint between the lateral condyle of the tibia and the head of the fibula. It is a gliding joint limited to a slight gliding movement.

6. Tibiofibular syndesmosis. This joint is formed by the junction of the distal end of the fibula and the fibular notch of the tibia. It is a slightly movable joint.

7. Ankle Joint. The ankle joint is between the body of the talus articulating with the ankle mortise. The mortise is the arch-like structure formed by the medial malleolus and inferior articular surface of the tibia and the lateral malleolus of the fibula. The ankle is a hinge joint. The movements permitted are flexion and extension.

8. Foot.

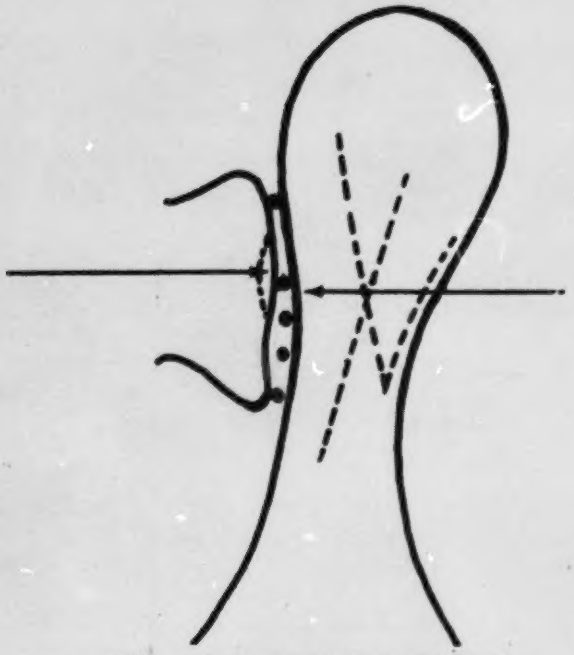
a. Intertarsal. The intertarsal articulations are between the individual tarsal bones. They are of the gliding type. The movement allowed is gliding.

b. Tarsometatarsal. The tarsometatarsal articulations are between the bases of the metatarsals and the distal row of tarsal bones. They are gliding joints. The movement permitted is gliding.

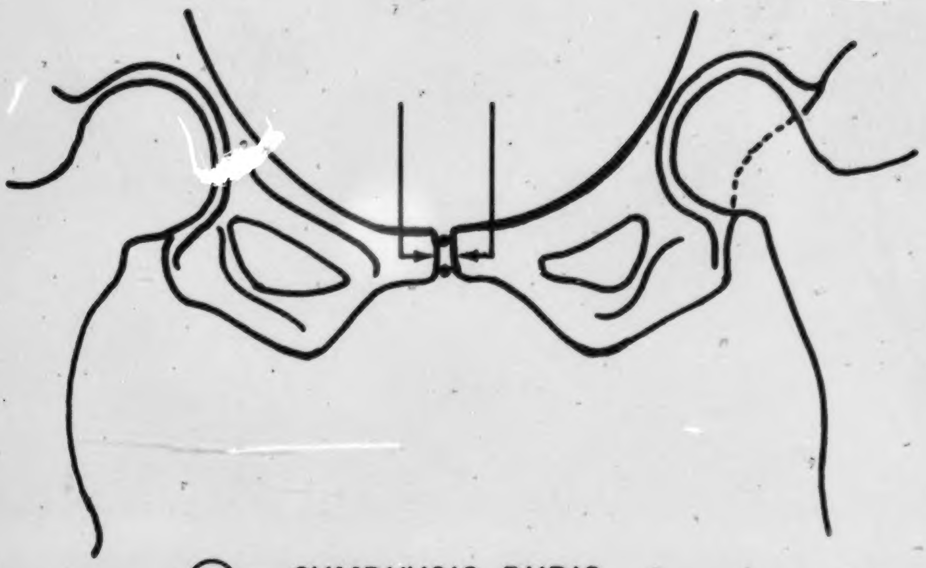
9. Intermetatarsal. The intermetatarsal articulations are between adjacent bases of the metatarsals. They are gliding joints. The movement permitted is gliding.

10. Metatarsophalangeal. The metatarsophalangeal joints are between the heads of the metatarsals articulating with the bases of the proximal phalanges. They are condyle-like articulations. The movements permitted are flexion and extension.

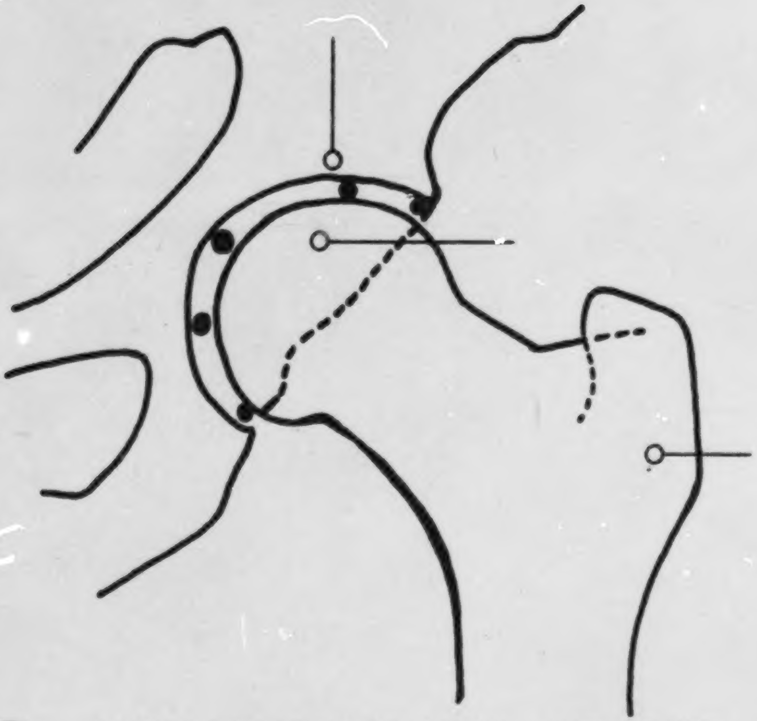
11. Interphalangeal. The interphalangeal joints are between the proximal and middle phalanges. They are hinge joints. The movements permitted are flexion and extension.



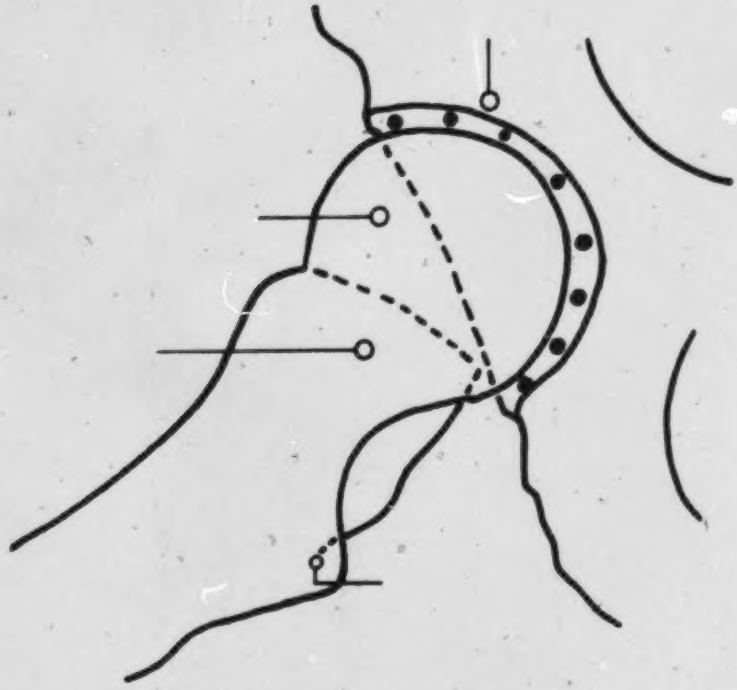
① SACROILIAC JOINT



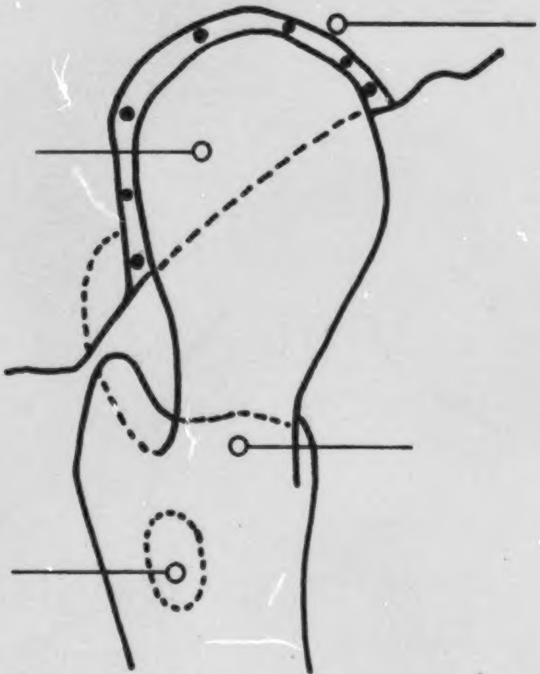
② SYMPHYSIS PUBIS



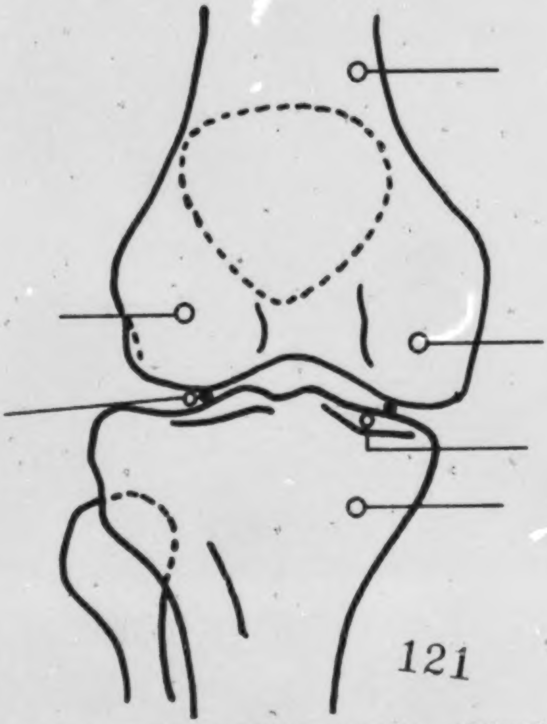
③ ANTEROPOSTERIOR VIEW HIP JOINT



④ HIP (Frog Position)

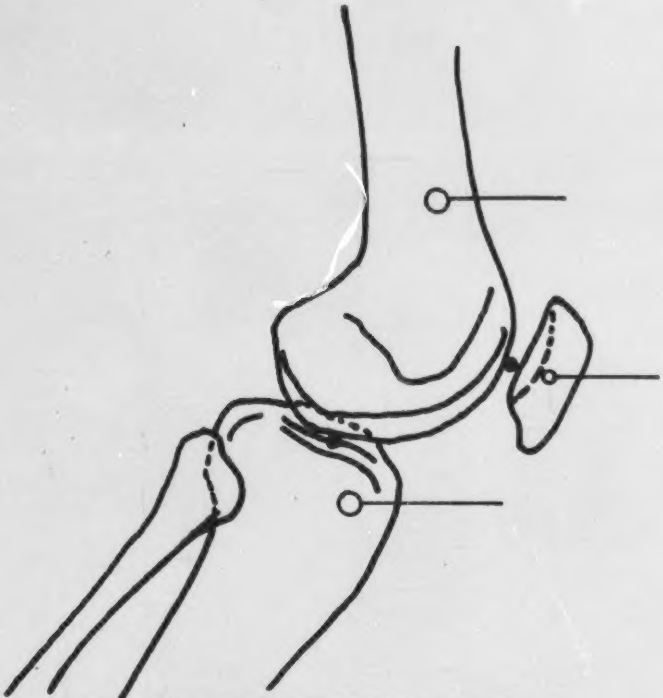


⑤ LATERAL VIEW–HIP •

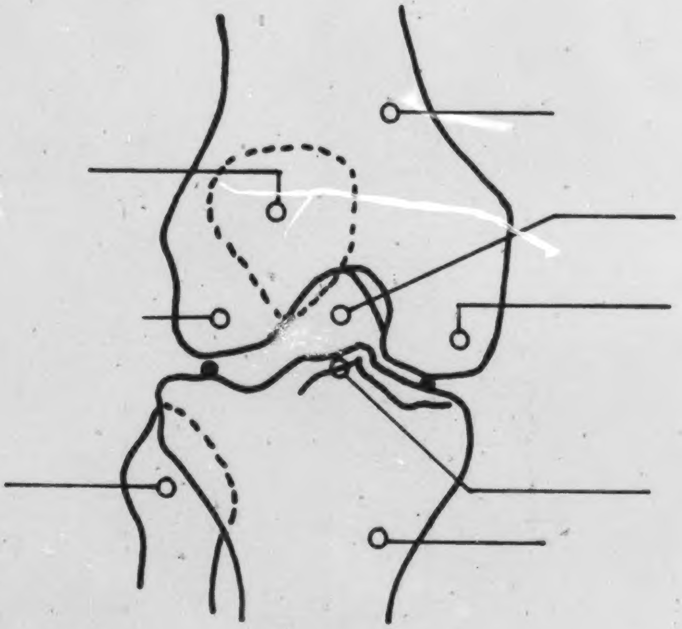


⑥ ANTEROPOSTERIOR VIEW KNEE •

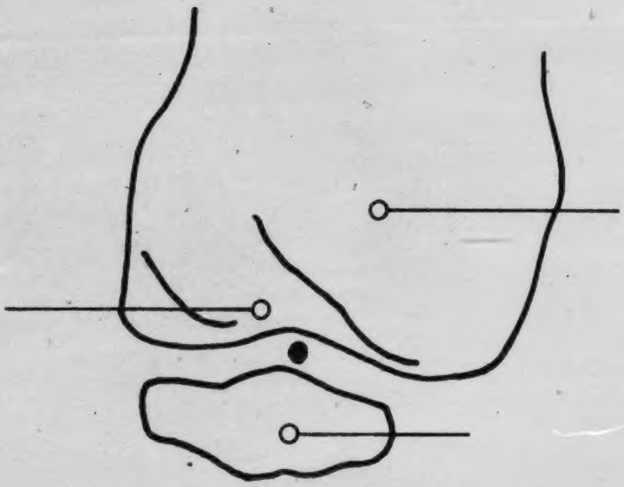
///



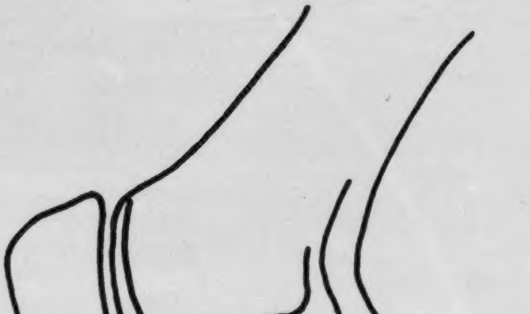
⑦ FEMOROPATELLAR •
AND KNEE JOINTS •



⑧ TUNNEL VIEW OF KNEE •

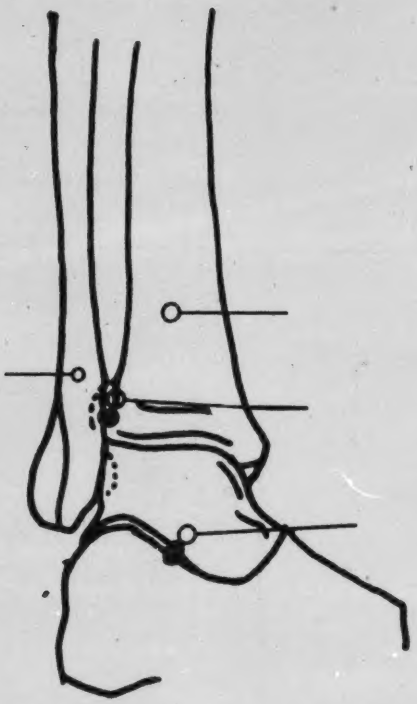


⑨ FEMOROPATELLAR JOINT •

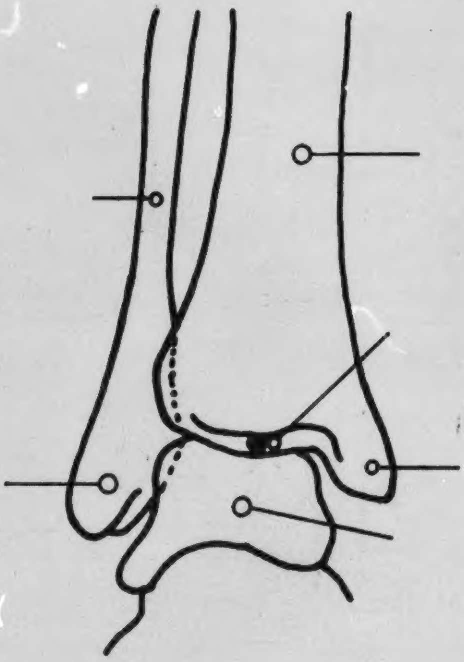


⑩ PROXIMAL TIBIOFIBULAR JOINT •

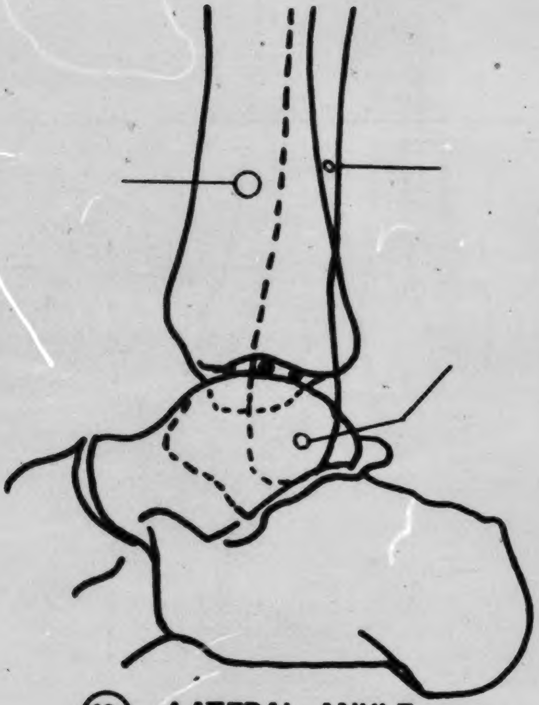
113



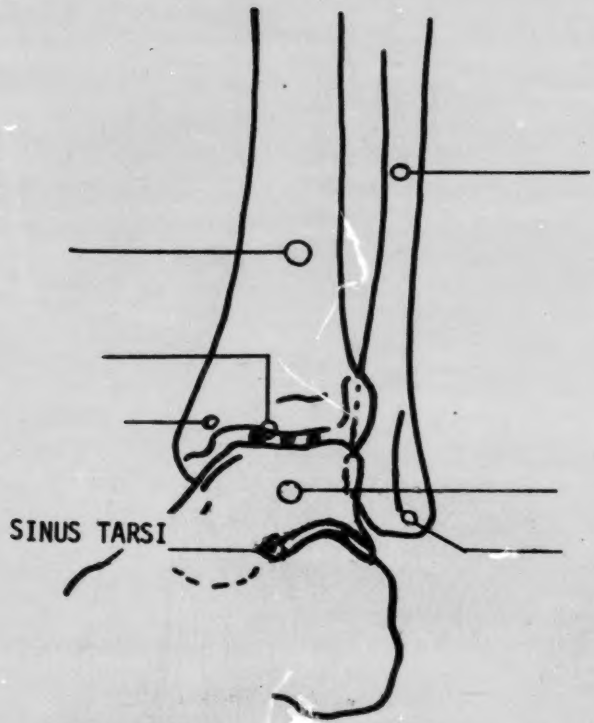
⑪ TIBIOFIBULAR SYNDESMOSIS •



⑫ ANTEROPOSTERIOR VIEW ANKLE JOINT •

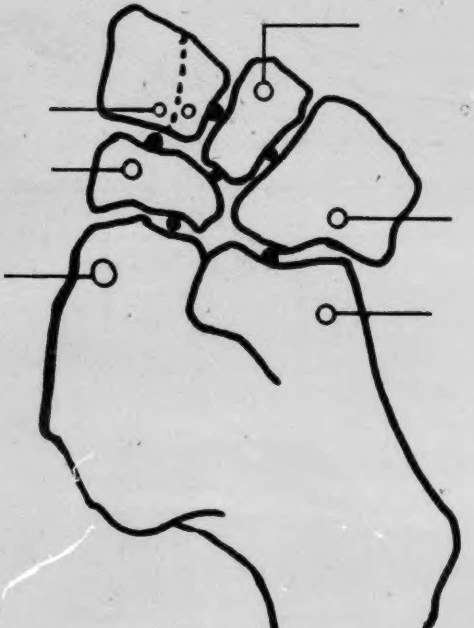


⑬ LATERAL ANKLE •

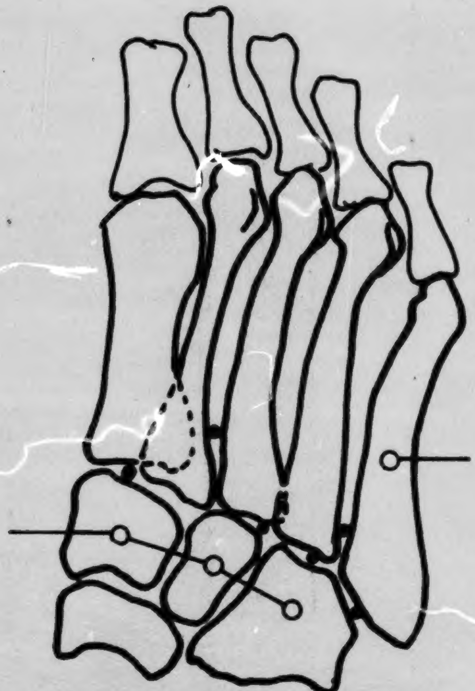

SINUS TARSI

⑭ OBLIQUE VIEW ANKLE •

115



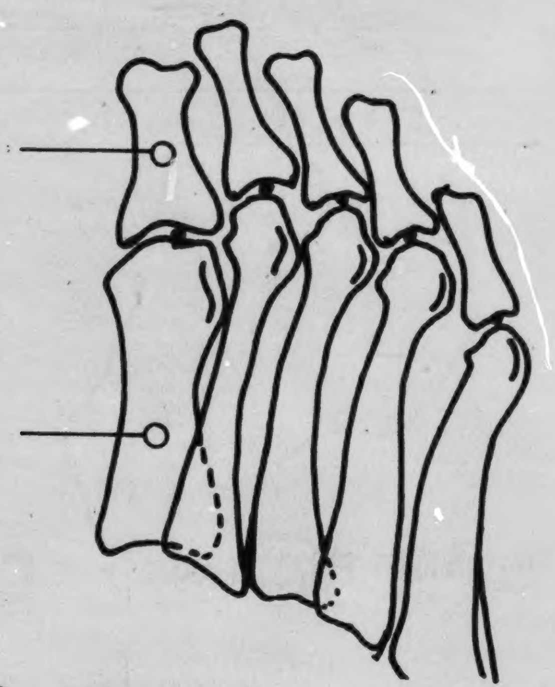
⑮ INTERTARSAL JOINTS



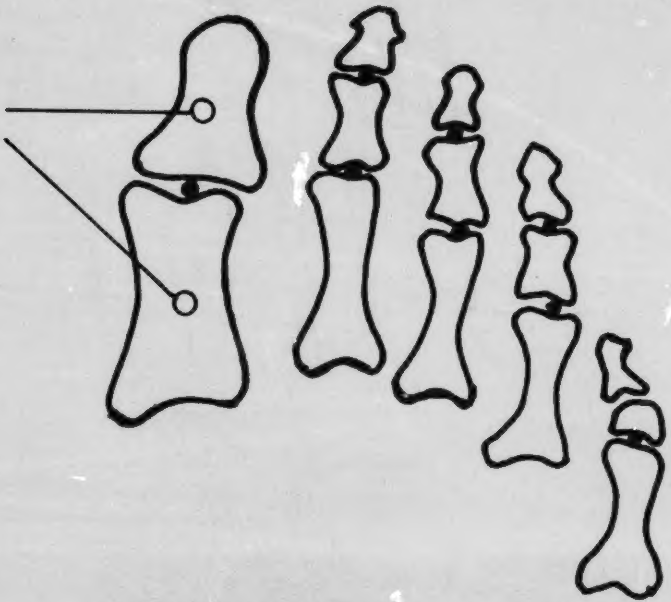
⑯ TARSOMETATARSAL AND INTERMETATARSAL JOINTS

82 h

116



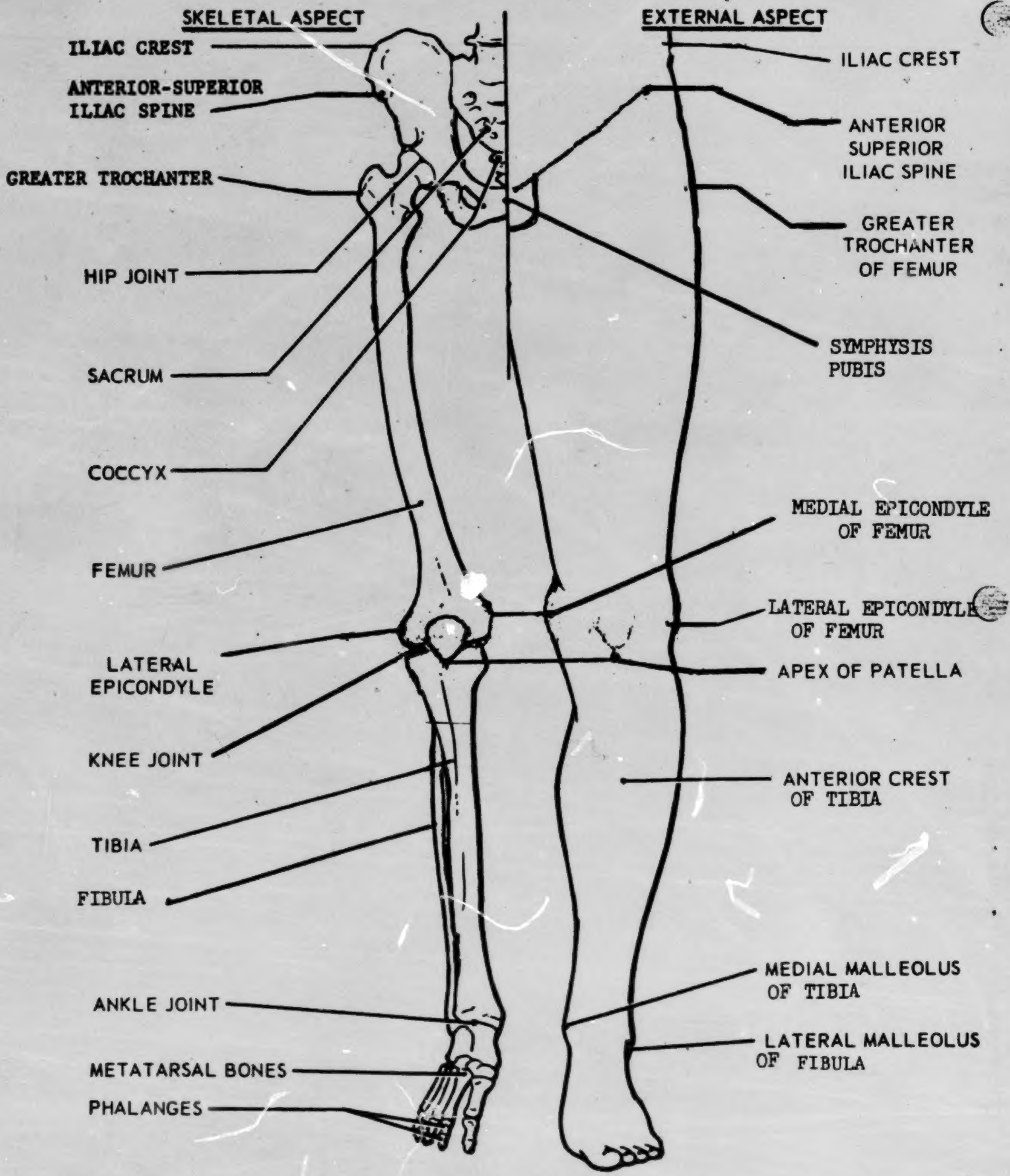
⑰ METATARSOPHALANGEAL JOINTS •



⑱ INTERPHALANGEAL JOINTS •

117

Palpation Points of the Lower Limb


SKELETAL ASPECT
EXTERNAL ASPECT
ILIAC CREST
ANTERIOR-SUPERIOR ILIAC SPINE
GREATER TROCHANTER
HIP JOINT
SACRUM
COCCYX
FEMUR
LATERAL EPICONDYLE
KNEE JOINT
TIBIA
FIBULA
ANKLE JOINT
METATARSAL BONES
PHALANGES
ILIAC CREST
ANTERIOR SUPERIOR ILIAC SPINE
GREATER TROCHANTER OF FEMUR
SYMPHYSIS PUBIS
MEDIAL EPICONDYLE OF FEMUR
LATERAL EPICONDYLE OF FEMUR
APEX OF PATELLA
ANTERIOR CREST OF TIBIA
MEDIAL MALLEOLUS OF TIBIA
LATERAL MALLEOLUS OF FIBULA

Correlation of Landmarks and Bones of the Lower Limb

Osteology of the Trunk

I. OUTLINE OF AXIAL SKELETON (80 Bones)

A. Skull (22 Bones)

1. Cranium "________________" (8 bones)

a. Frontal (1)

b. _______ (2)

c. Temporal (2)

d. _______ (1)

e. Sphenoid (1)

f. Ethmoid (1)

2. Facial skeleton (14 bones)

a. Nasal (2)

b. Lacrimal (2)

c. ___________ (2)

d. Zygoma or ____________(2)

e. __________ __________ conchae (2)

f. Palatine (2)

g. Vomer (1)

h. ___________(1)

B. Vertebral Column (26 Bones)

1. ____________vertebrae ( )

2. Dorsal or _____________vertebrae

3. ____________vertebrae (5)

4. Sacrum (1) 5 fused sacral elements

5. Coccyx (1) 4 fused coccygeal elements

C. Thoracic Cage (25 Bones)

1. Ribs (24)

2. Sternum (breast bone) (1)

D. Other Bones (Branchial Skeleton)

1. Hyoid (1)--a U-shaped bone situated just below the mandible

2. Auditory ossicles (6) situated in the middle ear

a. Malleus (2)

b. Incus (2)

c. Stapes (2)

II. OSTEOLOGY OF THE VERTEBRAL COLUMN

A. General Structure and Function

1. Pyramidal Structure

2. Vertebral Canal

3. Intervertebral Foramina

4. Intervertebral Disks

B. Vertebral Column as a Unit

1. Normal curvatures
    a. Regions

122

b. Classification

1) Primary curvature

2) Secondary curvature

2. Abnormal curvatures

133

C. Abbreviations and Numbering of Vertebrae

D. Types of Vertebrae

1. Typical

124

2. Atypical

E. Structure of Typical Vertebrae

135

F. Differentiating Characteristics

G. Atypical Vertebrae

1. C-1

2. C-2

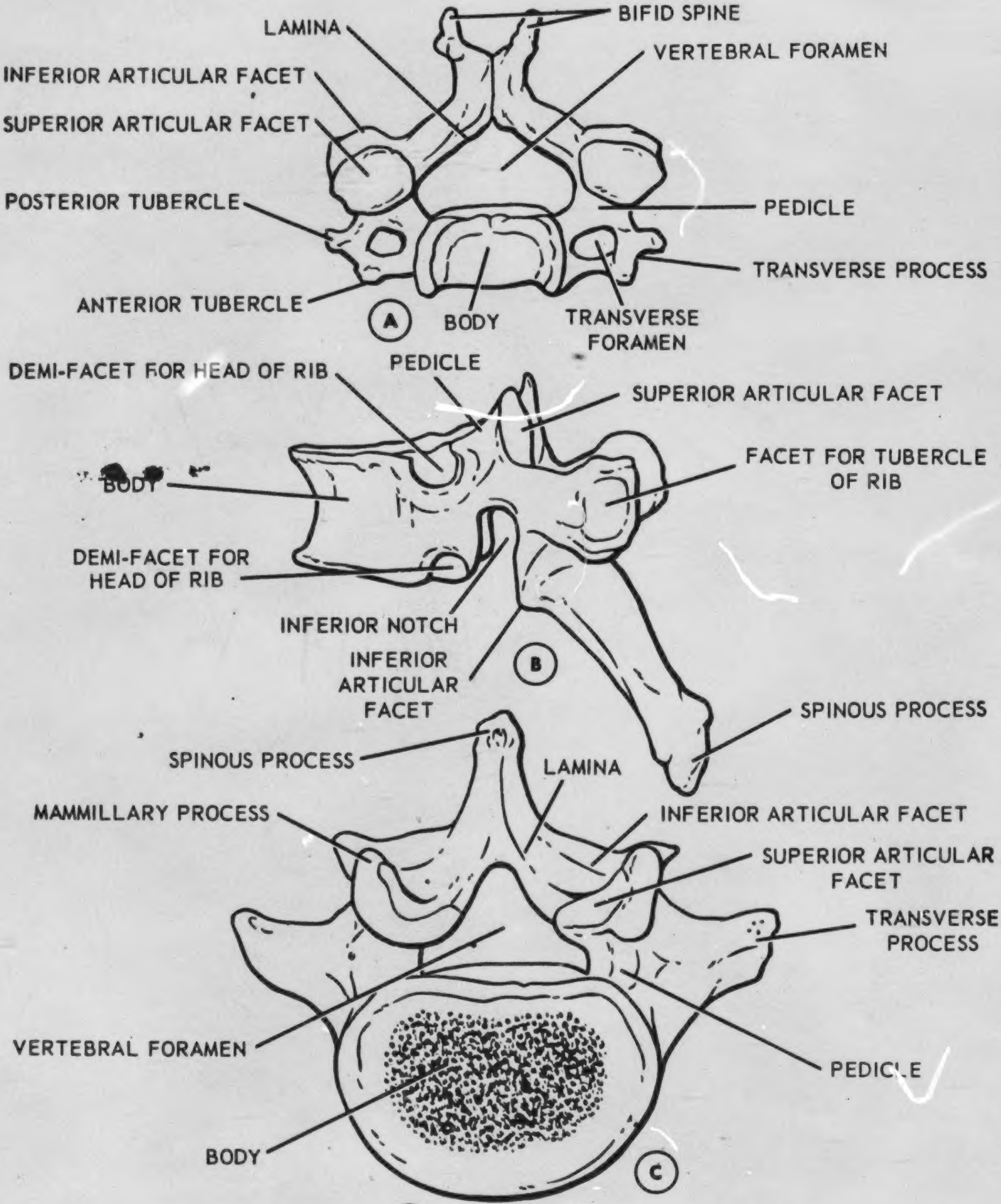
126

3. Sacrum

4. Coccyx

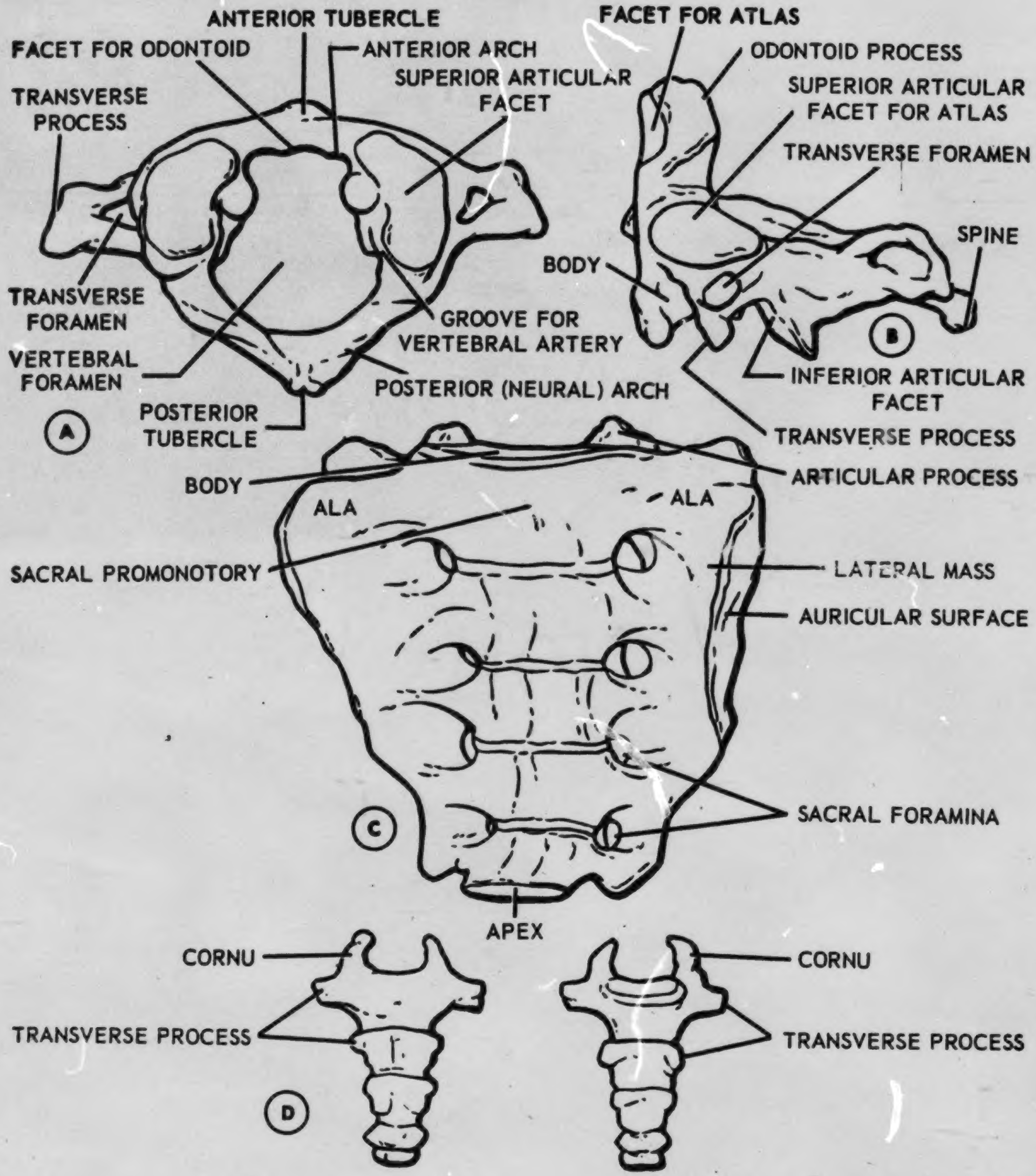
137

TYPICAL VERTEBRAE


BIFID SPINE
LAMINA
VERTEBRAL FORAMEN
INFERIOR ARTICULAR FACET
SUPERIOR ARTICULAR FACET
POSTERIOR TUBERCLE
PEDICLE
TRANSVERSE PROCESS
ANTERIOR TUBERCLE
A
BODY
TRANSVERSE FORAMEN
DEMI-FACET FOR HEAD OF RIB
PEDICLE
SUPERIOR ARTICULAR FACET
FACET FOR TUBERCLE OF RIB
BODY
DEMI-FACET FOR HEAD OF RIB
INFERIOR NOTCH
INFERIOR ARTICULAR FACET
B
SPINOUS PROCESS
SPINOUS PROCESS
LAMINA
MAMMILLARY PROCESS
INFERIOR ARTICULAR FACET
SUPERIOR ARTICULAR FACET
TRANSVERSE PROCESS
VERTEBRAL FORAMEN
PEDICLE
BODY
C

Ⓐ CERVICAL
Ⓑ DORSAL
Ⓒ LUMBAR

ATYPICAL VERTEBRAE


ANTERIOR TUBERCLE
FACET FOR ODONTOID
ANTERIOR ARCH
SUPERIOR ARTICULAR FACET
TRANSVERSE PROCESS
TRANSVERSE FORAMEN
VERTEBRAL FORAMEN
GROOVE FOR VERTEBRAL ARTERY
POSTERIOR (NEURAL) ARCH
POSTERIOR TUBERCLE
A
FACET FOR ATLAS
ODONTOID PROCESS
SUPERIOR ARTICULAR FACET FOR ATLAS
TRANSVERSE FORAMEN
SPINE
BODY
B
INFERIOR ARTICULAR FACET
TRANSVERSE PROCESS
ARTICULAR PROCESS
BODY
ALA
ALA
SACRAL PROMONOTORY
LATERAL MASS
AURICULAR SURFACE
SACRAL FORAMINA
C
APEX
CORNU
CORNU
TRANSVERSE PROCESS
TRANSVERSE PROCESS
D

Ⓐ ATLAS
Ⓑ AXIS
Ⓒ SACRUM
Ⓓ COCCYX

III. OSTEOLOGY OF THE THORACIC CAGE

A. General Structure and Function

B. Ribs

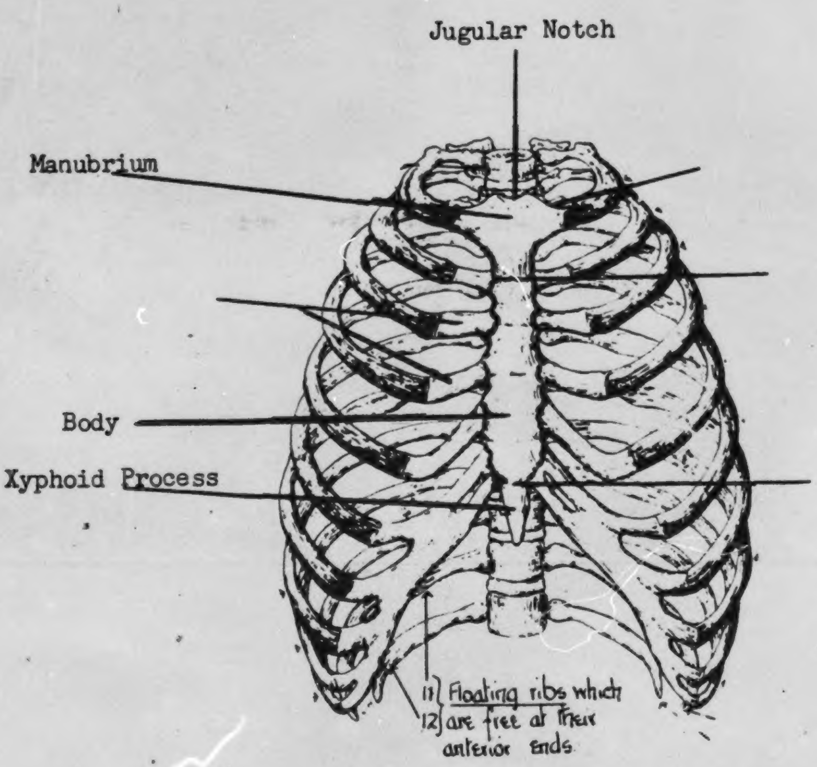
1. Classification

2. Structure

130

C. Sternum

141

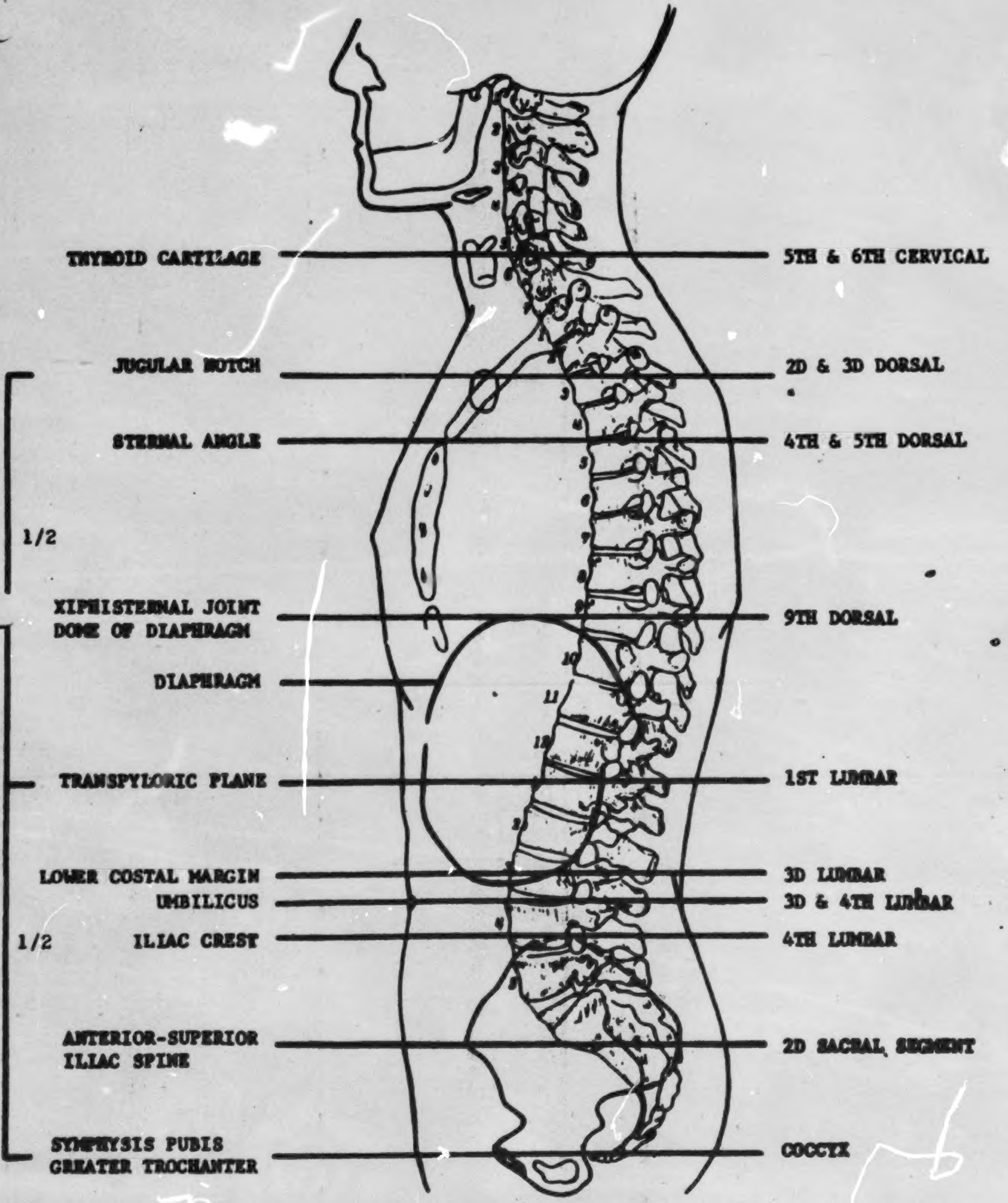

Jugular Notch
Manubrium
Body
Xyphoid Process
11} Floating ribs which
12} are free at their
anterior ends

Sternum and Ribs (Anterior View)

132

Palpation Points of the Trunk

143


THYROID CARTILAGE
5TH & 6TH CERVICAL
JUGULAR NOTCH
2D & 3D DORSAL
STERNAL ANGLE
4TH & 5TH DORSAL
1/2
XIPHISTERNAL JOINT
DOME OF DIAPHRAGM
9TH DORSAL
DIAPHRAGM
TRANSPYLORIC PLANE
1ST LUMBAR
LOWER COSTAL MARGIN
3D LUMBAR
UMBILICUS
3D & 4TH LUMBAR
1/2
ILIAC CREST
4TH LUMBAR
ANTERIOR-SUPERIOR
ILIAC SPINE
2D SACRAL SEGMENT
SYMPHYSIS PUBIS
GREATER TROCHANTER
COCCYX

VERTEBRAL LANDMARKS

INTERNAL ANATOMY

UROGENITAL SYSTEM

I. URINARY SYSTEM

A. Kidneys

1. Description

2. Divisions of the kidney and characteristics of the component structures.

   a. Cortex

      Structure and function of the nephron unit

   b. Medullary portion

   c. Renal sinus

3. Location of the kidneys

4. **Functions of the kidneys**

B. **Ureters**

   1. Location

2. Structure

3. Function

C. Urinary Bladder
  1. Description
  2. Orifices
  3. Function
  4. Location of the bladder

138

D. Urethra

1. Description and location

2. Structure

a. Female

b. Male

3. Function

II. GENITAL SYSTEM

A. Female Reproductive System

Gonads, oviducts, uterus, vagina, and external genitalia

1. Description and location

2. Structure

a. Gonads

149

b. Oviducts

c. Uterus

d. Vagina

e. External genitalia

f. External openings (anterior to posterior)

140

3. Functions (the menstrual cycle)

B. Male Reproductive System

Description, location and functions

1. Gonads

2. Excretory ducts

a. Epididymis

b. Vas deferens

151

c. Ejaculatory duct

3. Accessory structures

a. Seminal vesicles

b. Prostate gland

c. Penis

C. Reproduction

1. The spermatozoa
2. The ova
3. The zygote

D. Radiographic Examinations

1. Intravenous pyelography

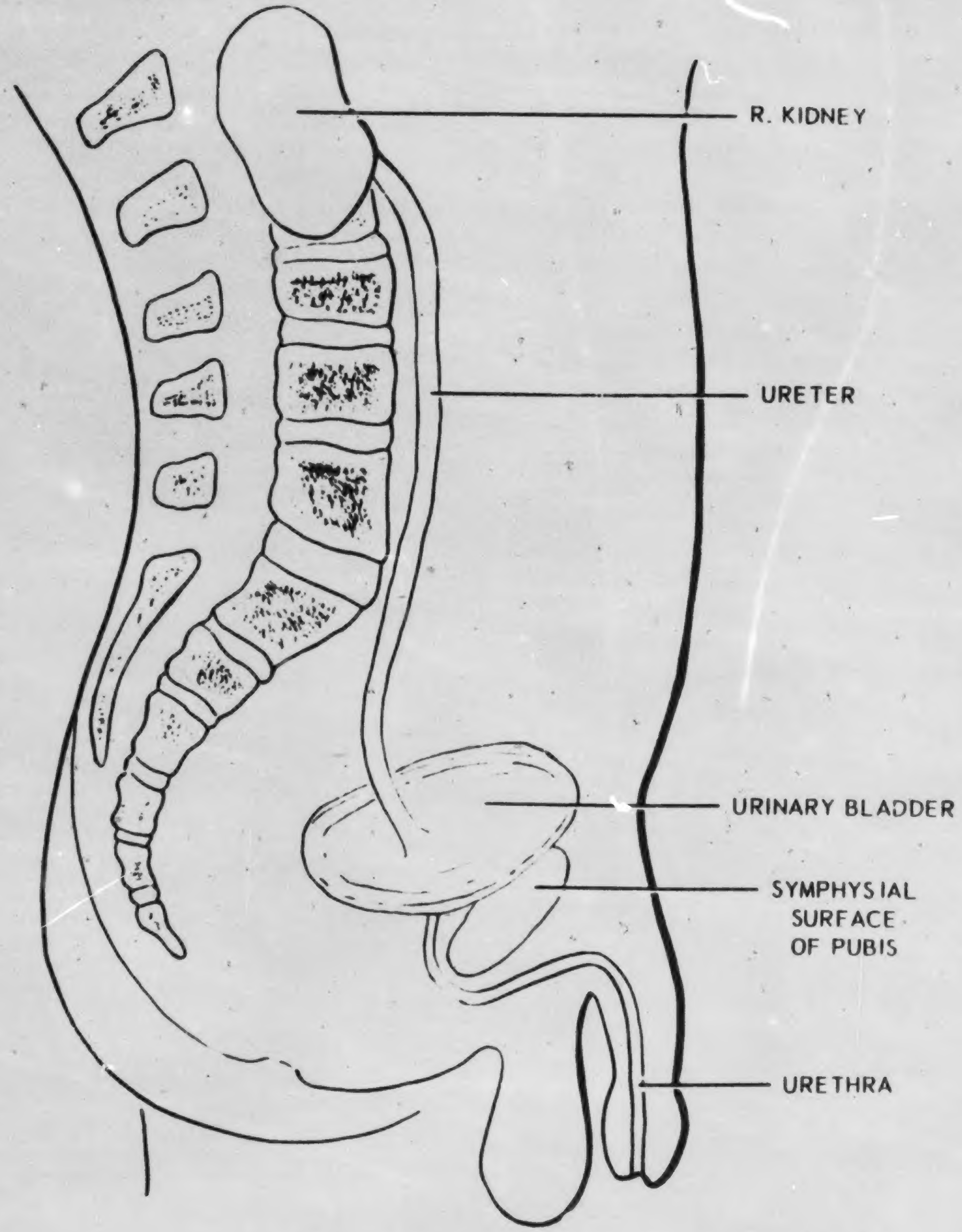
2. Retrograde pyelography

3. Cystography

4. Urethrography

5. Uterosalpingography

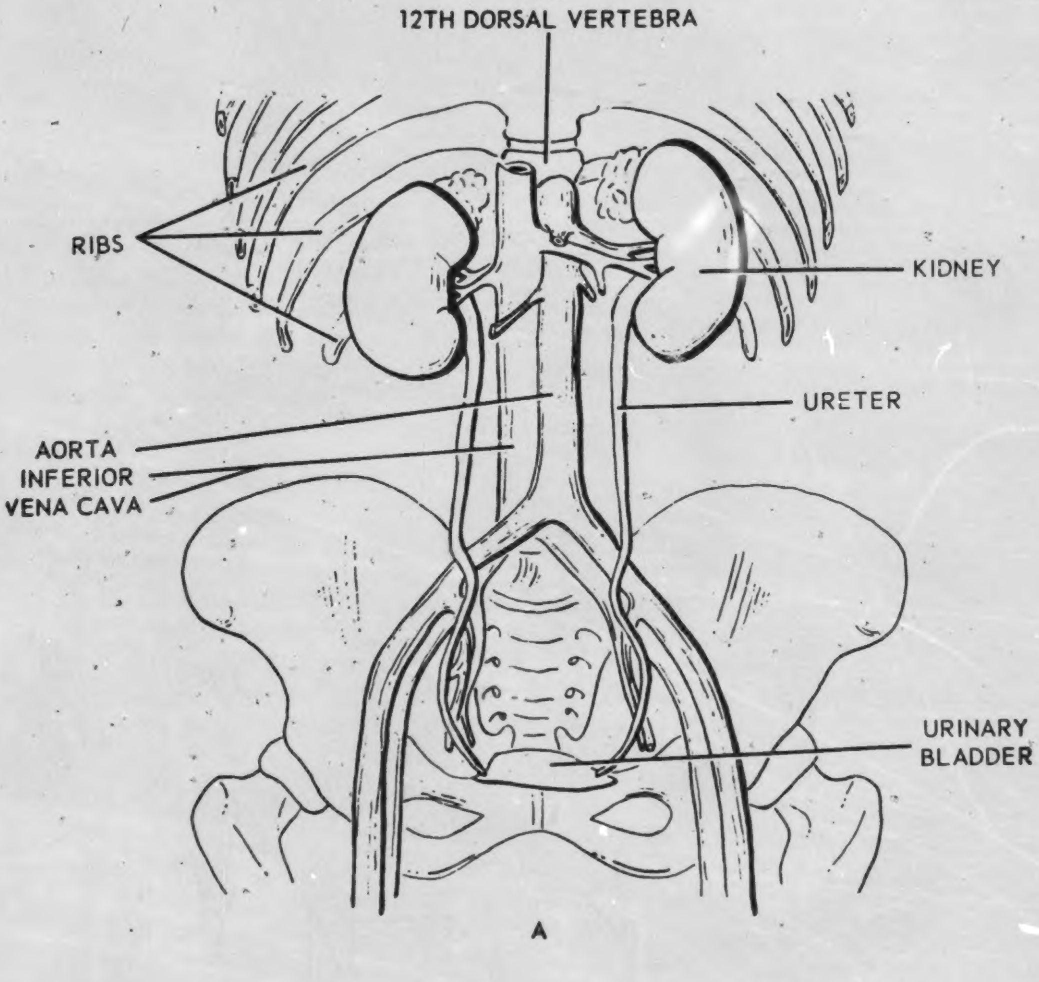
6. Epididymography


R. KIDNEY
URETER
URINARY BLADDER
SYMPHYSIAL SURFACE OF PUBIS
URETHRA

B

Male Urinary System

145


12TH DORSAL VERTEBRA
RIBS
KIDNEY
URETER
AORTA
INFERIOR
VENA CAVA
URINARY
BLADDER
A

Urinary System

RESPIRATORY SYSTEM

I. GENERAL

A. Structures

Nose, nasal chambers, nasal conchae, paranasal sinuses, nasopharynx, oropharynx, larynx, trachea, bronchi, and the bronchioles and alveoli of the lungs.

All (except alveoli) lined with a Ciliated Mucus Membrane which is highly vascularised.

B. Functions

II. AIR PASSAGES

A. Nose

Description of Nose and Nasal Chambers

B. Paranasal Sinuses

C. Pharynx

Divisions	Locations	Functions

148

D. Larynx

E. Trachea

F. Bronchi

159

III. LUNGS

IV. THORAX

Description of the Cage and its boundaries

A. Parietal Pleura

B. The Pulmonary Pleura

C. Mediastinum

1. Description
2. Location
3. Contents

D. Costophrenic Angles

V. FUNCTIONS (MECHANICS OF RESPIRATION)

152

VI. RADIOGRAPHIC EXAMINATIONS

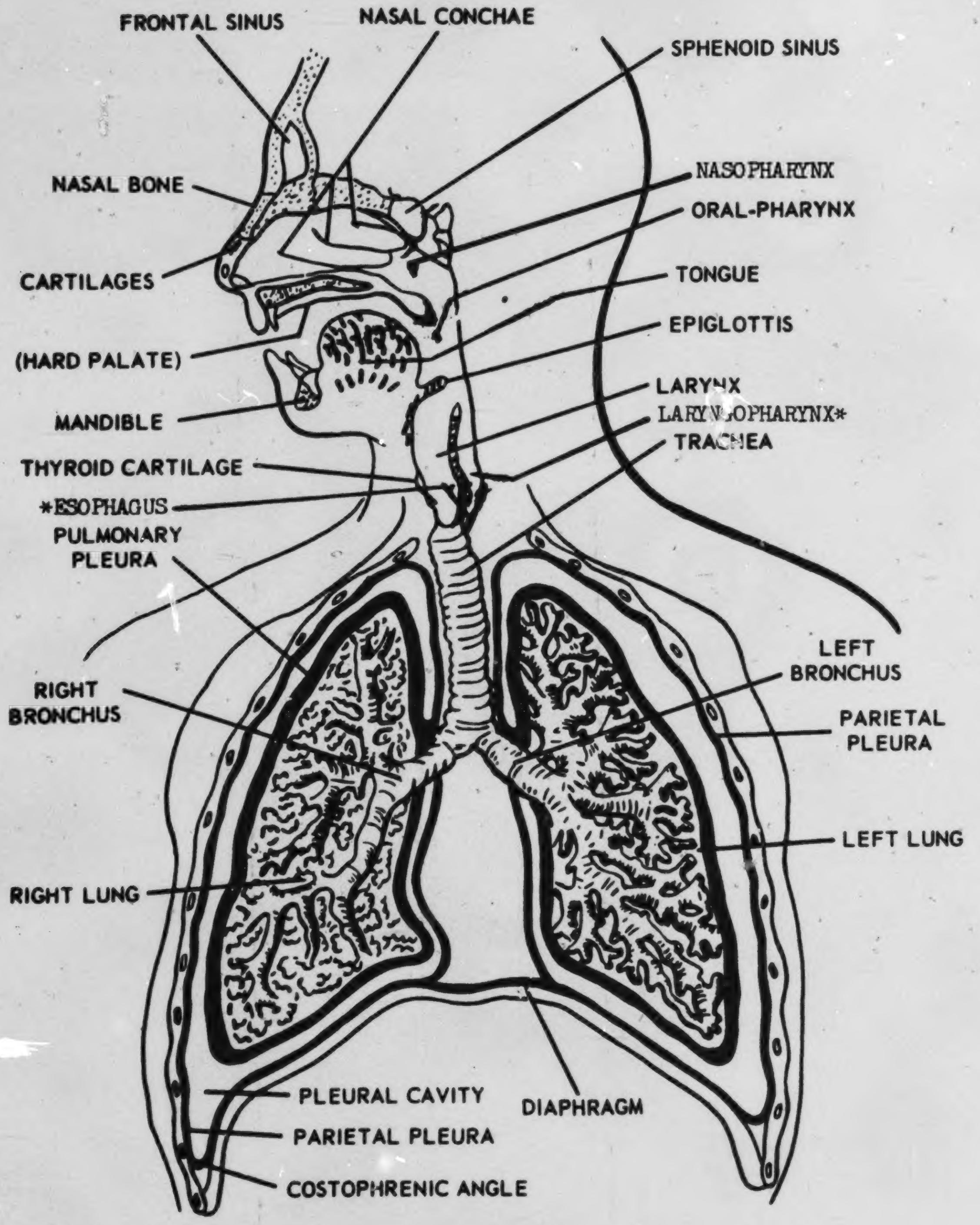
A. Posteroanterior (PA)

B. Lateral

C. Lordotic

D. Bronchongraphy

163


FRONTAL SINUS
NASAL CONCHAE
SPHENOID SINUS
NASAL BONE
NASOPHARYNX
ORAL-PHARYNX
CARTILAGES
TONGUE
(HARD PALATE)
EPIGLOTTIS
MANDIBLE
LARYNX
LARYNGOPHARYNX*
TRACHEA
THYROID CARTILAGE
*ESOPHAGUS
PULMONARY PLEURA
LEFT BRONCHUS
RIGHT BRONCHUS
PARIETAL PLEURA
LEFT LUNG
RIGHT LUNG
PLEURAL CAVITY
DIAPHRAGM
PARIETAL PLEURA
COSTOPHRENIC ANGLE

Respiratory System

*Part of Digestive System

154

NERVOUS SYSTEM

I. DIVISIONS

A. Central Nervous System (CNS)

1.

2.

B. Peripheral Nervous System

1.

2.

C. Autonomic Nervous System

1.

2.

II. TERMS

A. Neuron-

1. Dendrite-

2. Cell body-

3. Axon-

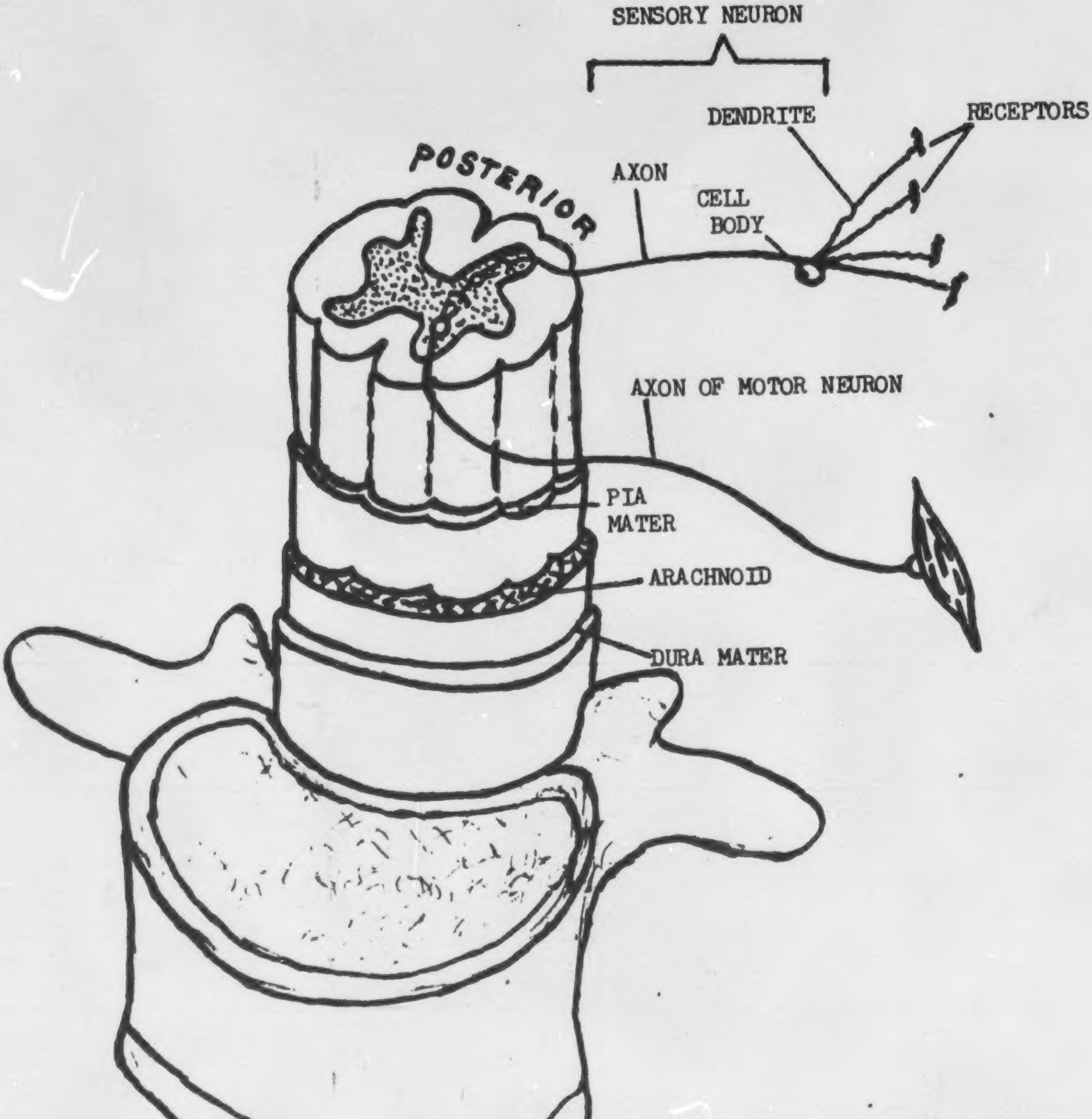
4. Synapse-

B. Sensory neuron-

C. Motor neuron-

165

D. Reflex arc-


SENSORY NEURON
DENDRITE
RECEPTORS
POSTERIOR
AXON
CELL BODY
AXON OF MOTOR NEURON
PIA MATER
ARACHNOID
DURA MATER

SECTION OF SPINAL CORD SHOWING THE MENINGES AND REFLEX ARC

156

III. CENTRAL NERVOUS SYSTEM (CNS)

A. Brain-

1. Structures and functions

    a. Cerebrum-

        1)

        2)

    b. Cerebellum

        1)

        2)

    c. Medulla oblongata

        1)

        2)

2. Ventricles

    a. Lateral (2)

        1)

        2)

    b. Third

        1)

        2)

    c. Fourth

        1)

        2)

167

B. Spinal cord - extension of the brain.

1.

2.

C. Meninges - Protective covering for the brain and spinal cord.

1.

2.

3.

4. Associated terms

a. Subarachnoid space -

b. Meningitis -

D. Cerebrospinal fluid - CSF

1.

2.

3.

4.

IV. PERIPHERAL NERVOUS SYSTEM

A. Cranial nerves

1.

2.

3.

B. Spinal nerves

1.

2.

3.

158

V. AUTONOMIC NERVOUS SYSTEM

A. Sympathetic Division

1.

2.

3.

4.

5.

B. Parasympathetic Division

1.

2.

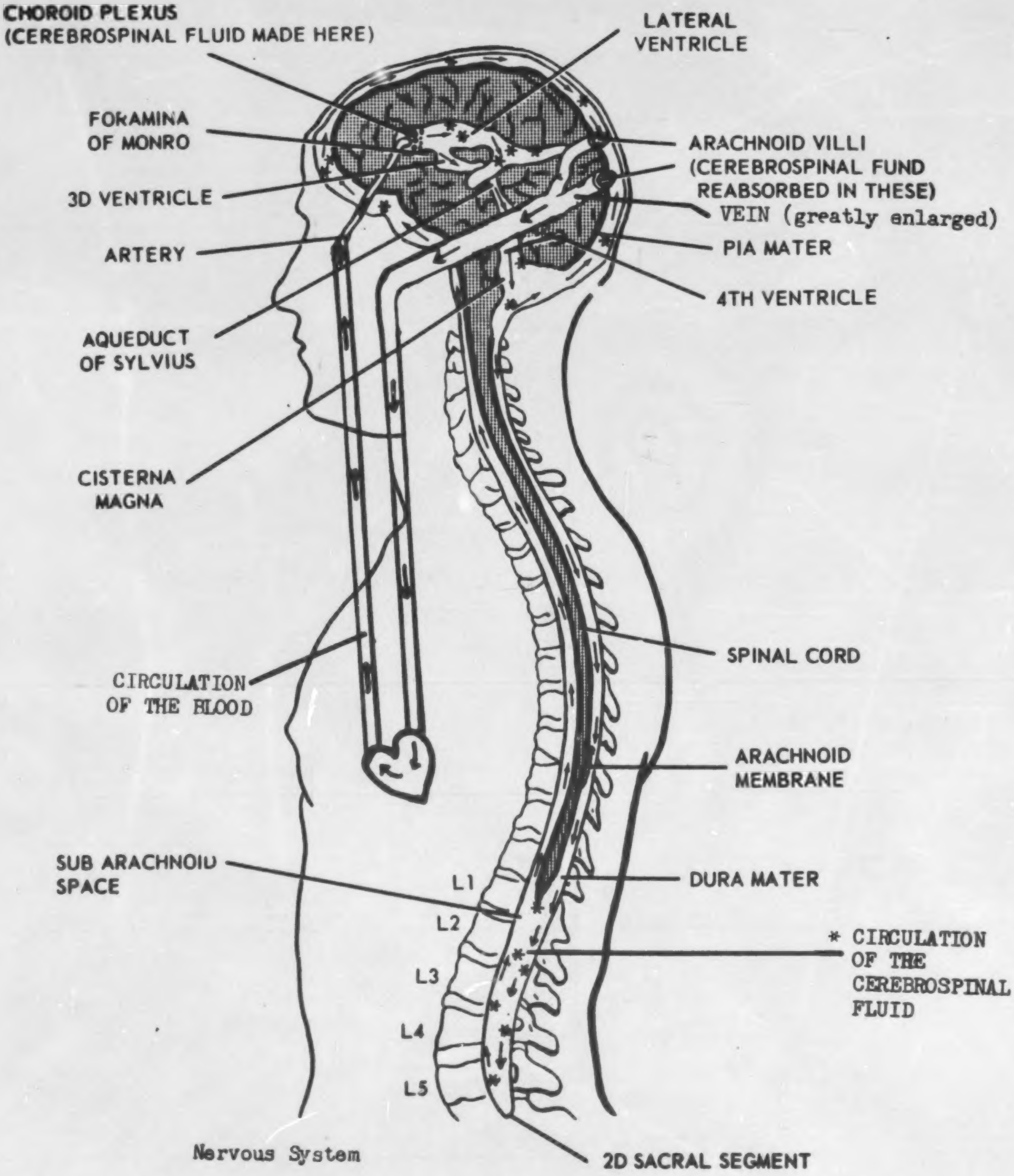
VI. RADIOGRAPHIC EXAMINATIONS OF THE NERVOUS SYSTEM

A. Ventriculography -

B. Pneumoencephalography -

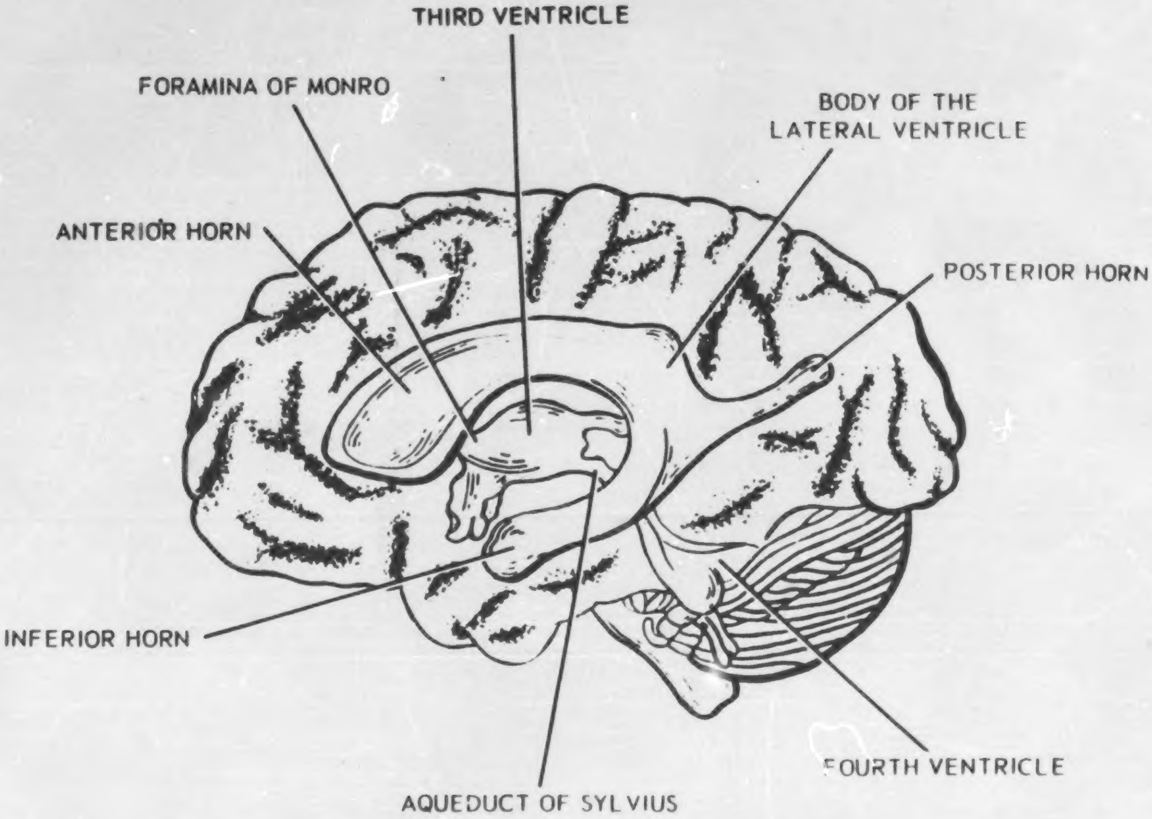
C. Myelography -

169


CHOROID PLEXUS
(CEREBROSPINAL FLUID MADE HERE)
LATERAL VENTRICLE
FORAMINA OF MONRO
ARACHNOID VILLI
(CEREBROSPINAL FUND REABSORBED IN THESE)
3D VENTRICLE
VEIN (greatly enlarged)
ARTERY
PIA MATER
4TH VENTRICLE
AQUEDUCT OF SYLVIUS
CISTERNA MAGNA
SPINAL CORD
CIRCULATION OF THE BLOOD
ARACHNOID MEMBRANE
SUB ARACHNOID SPACE
L1
DURA MATER
L2
L3
* CIRCULATION OF THE CEREBROSPINAL FLUID
L4
L5
2D SACRAL SEGMENT

Nervous System

160


THIRD VENTRICLE
FORAMINA OF MONRO
BODY OF THE LATERAL VENTRICLE
ANTERIOR HORN
POSTERIOR HORN
INFERIOR HORN
FOURTH VENTRICLE
AQUEDUCT OF SYLVIUS

A

171

Ventricles of the Brain

Body Types and Regions of the Abdomen

I. BODY TYPES

A. ____________________The body is large and heavy in weight, and the bony framework is thick.

B. ____________________The body is similar to the hypersthenic type, but modified by the elongation of the abdomen and the thorax.

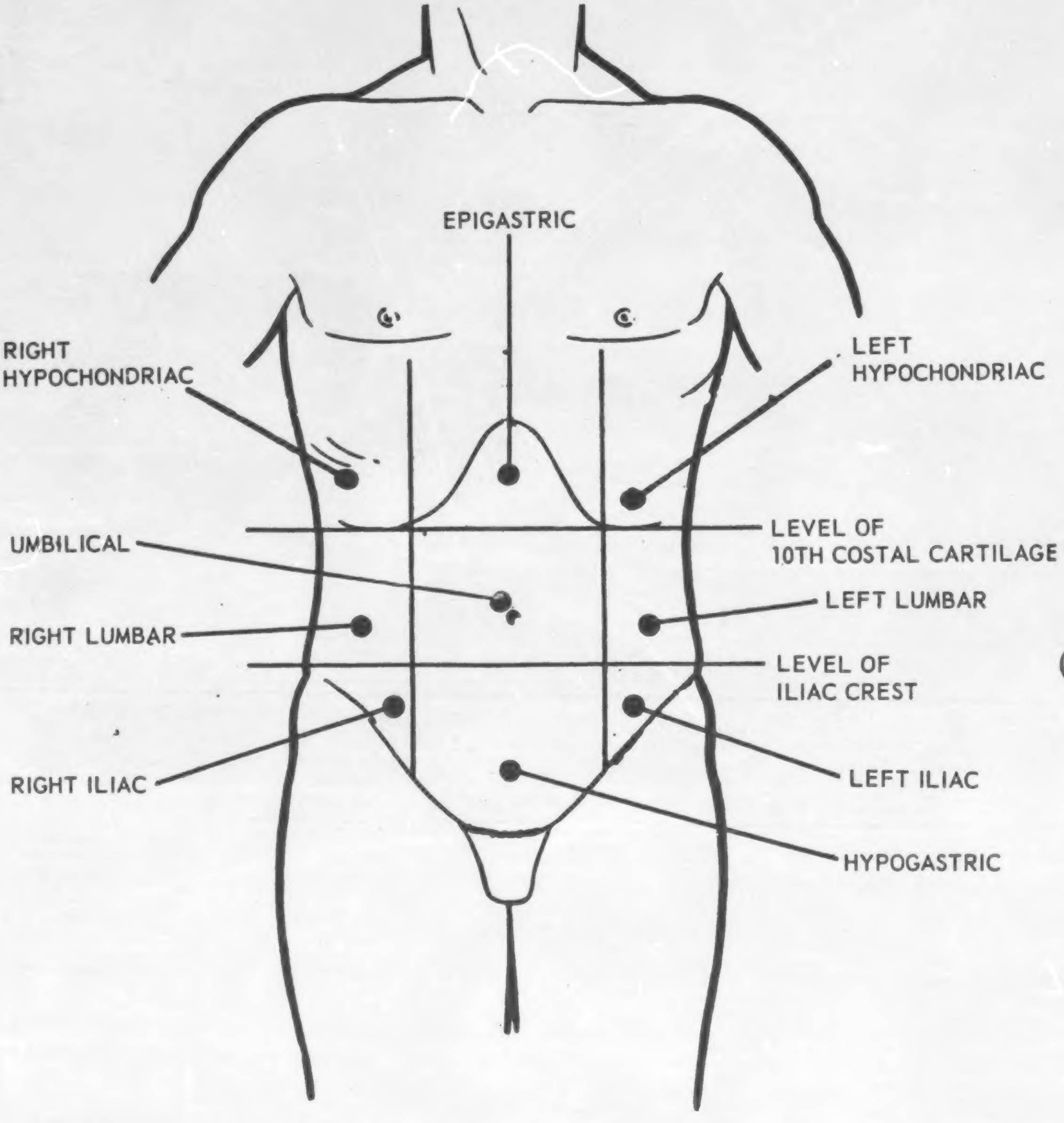
C. ____________________The body is slender and light in weight, and the bony framework is delicate.

D. ____________________The body is similar to the asthenic type, but the stomach, intestines, gall bladder are situated higher in the abdomen.

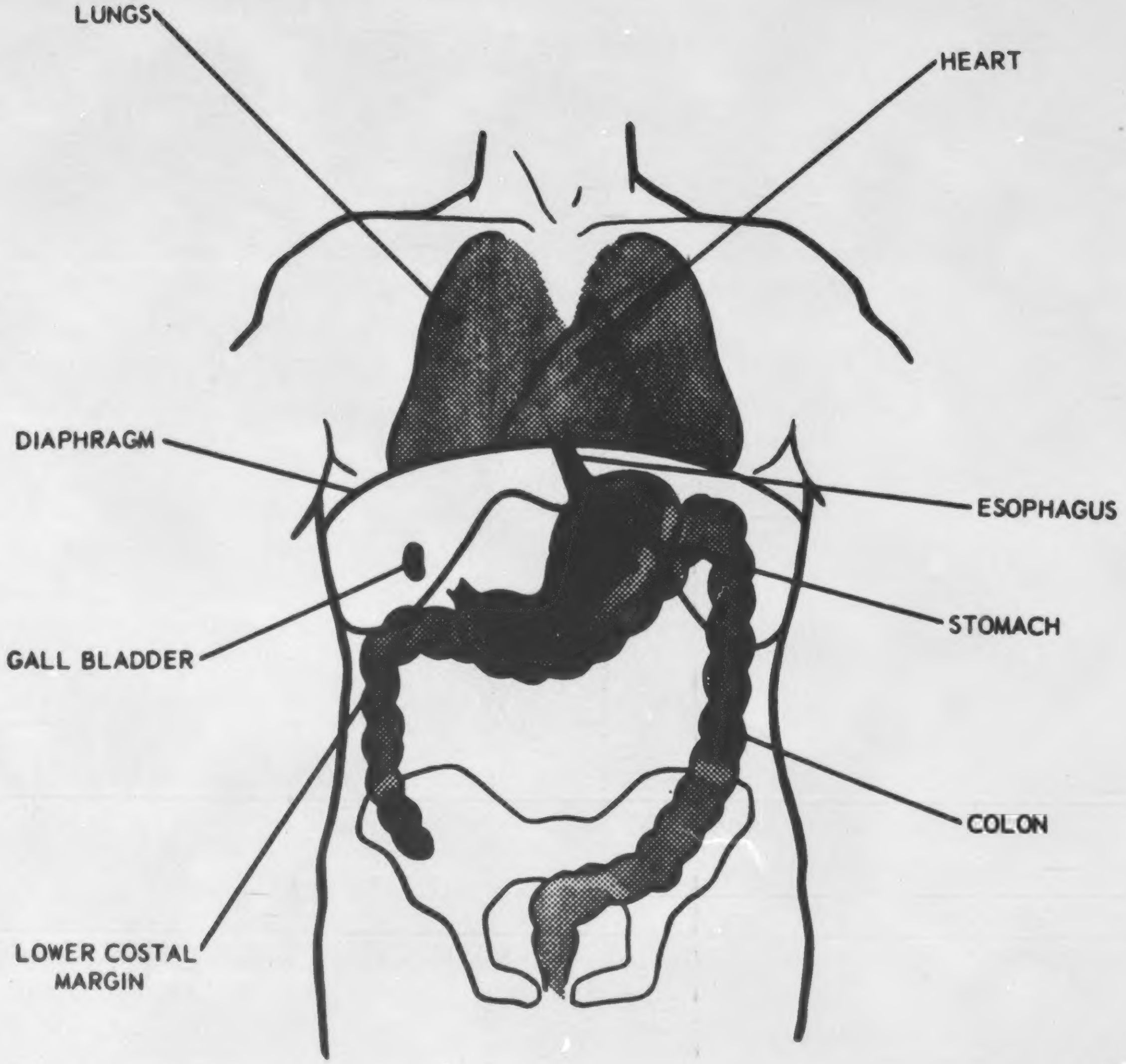
II. REGIONS OF THE ABDOMEN

For the purposes of description, the abdomen is divided into nine regions by means of two horizontal and two vertical lines. The upper horizontal lines pass through the tenth costal cartilage inferiorly. The lower line passes through the level of the iliac crests. Each vertical line passes through a point midway the length of a line drawn from the anterior superior iliac spine to the symphysis pubis.

162


EPIGASTRIC
RIGHT HYPOCHONDRIAC
LEFT HYPOCHONDRIAC
UMBILICAL
LEVEL OF 10TH COSTAL CARTILAGE
LEFT LUMBAR
RIGHT LUMBAR
LEVEL OF ILIAC CREST
RIGHT ILIAC
LEFT ILIAC
HYPOGASTRIC

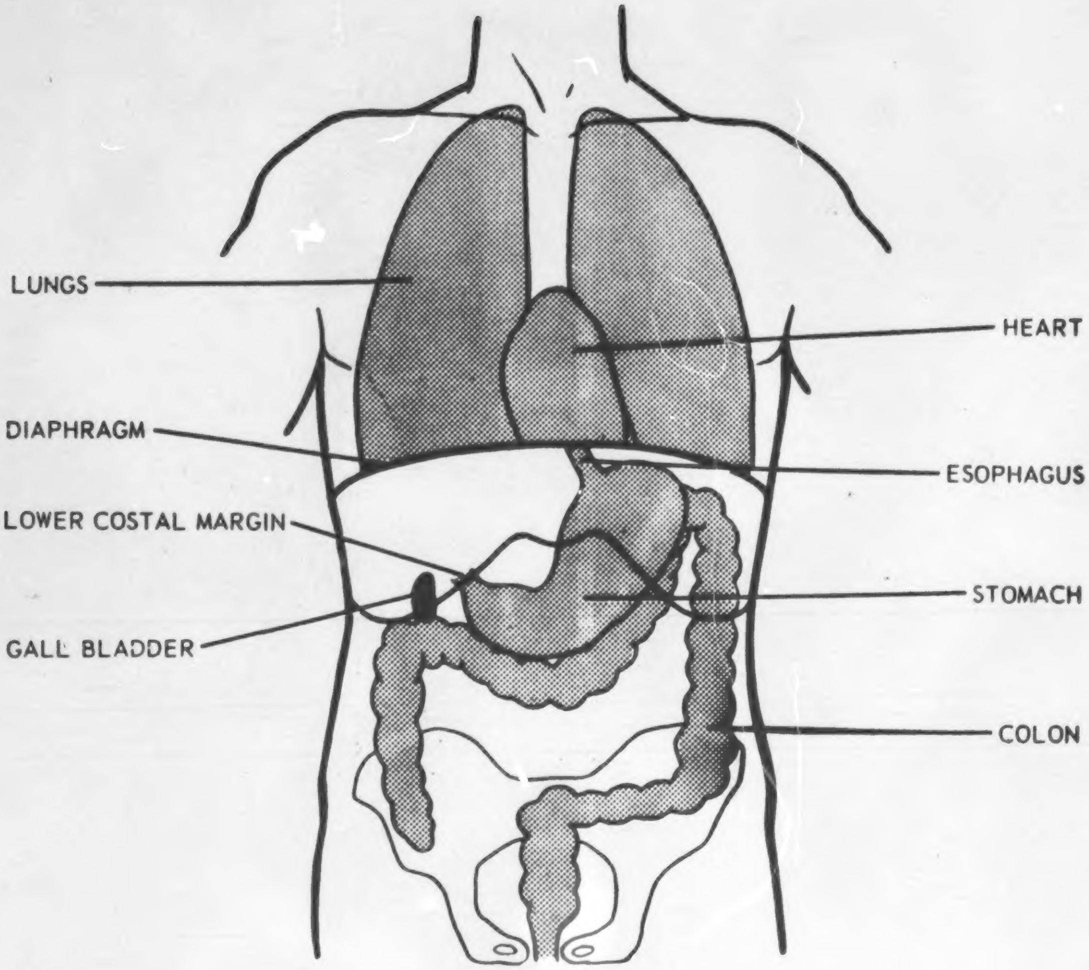
Regions of the Abdominal Cavity


LUNGS
HEART
DIAPHRAGM
ESOPHAGUS
STOMACH
GALL BLADDER
COLON
LOWER COSTAL MARGIN

HYPERSTHENIC
(5 PERCENT OF PATIENTS)

CHARACTERISTICS. MASSIVE BUILD, THORAX IS BROAD AND SHORT, THE HEART IS BROAD AND SQUAT, AND THE DOME OF THE DIAPHRAGM IS HIGH. THE STOMACH, COLON, AND GALL BLADDER ARE SITUATED HIGH IN THE ABDOMEN.

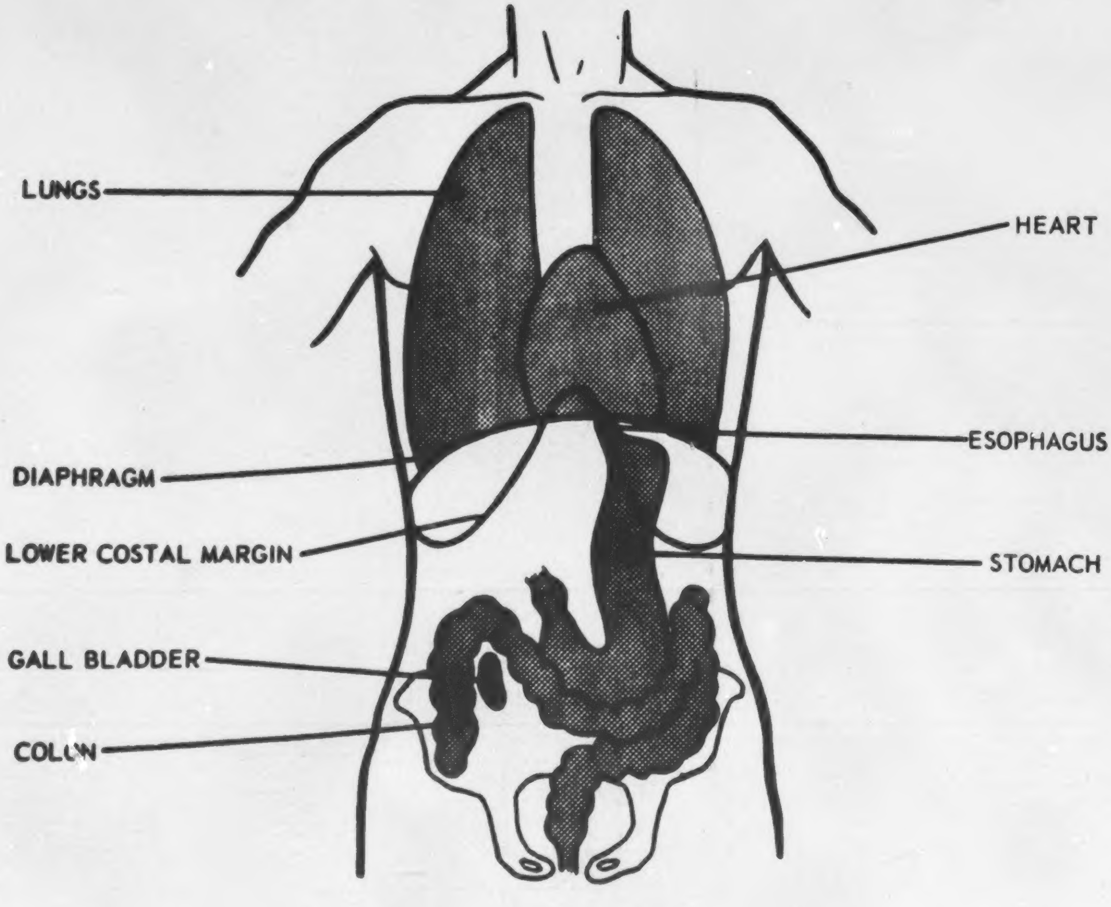
164


LUNGS
HEART
DIAPHRAGM
ESOPHAGUS
LOWER COSTAL MARGIN
STOMACH
GALL BLADDER
COLON

STHENIC
(48 PERCENT OF PATIENTS)

CHARACTERISTICS: VERY SIMILAR TO HYPERSTHENIC TYPE, BUT MODIFIED BY THE ELONGATION OF THE ABDOMEN AND THORAX.

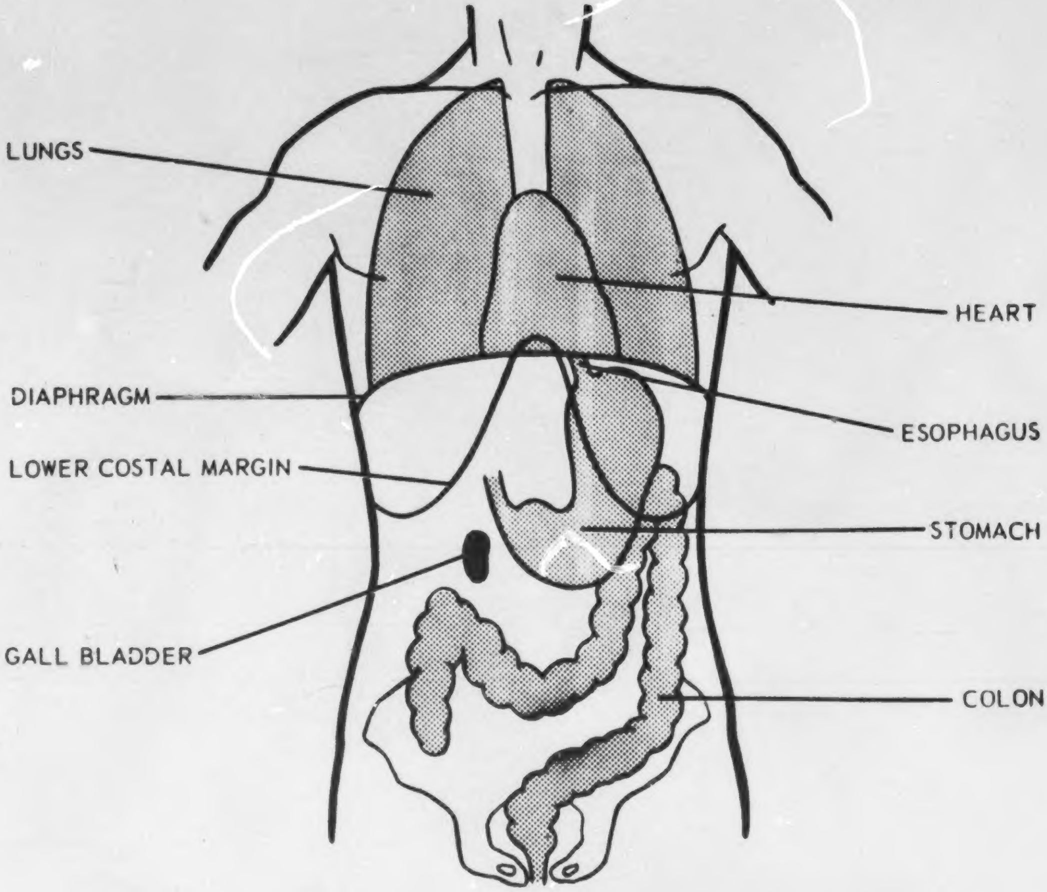
175


LUNGS
HEART
DIAPHRAGM
ESOPHAGUS
LOWER COSTAL MARGIN
STOMACH
GALL BLADDER
COLON

ASTHENIC
(12 PERCENT OF PATIENTS)

CHARACTERISTICS: SLENDER BUILD, ELONGATED NARROW THORAX, THE HEART AND LUNGS ARE NARROW AND ELONGATED. THE DIAPHRAGM IS LOW, THE ABDOMEN IS SHALLOW, THE STOMACH AND COLON LIE IN THE LOWER PORTION OF THE ABDOMEN, AND THE GALL BLADDER IS LOW AND CLOSE TO THE MIDLINE.

166


LUNGS
HEART
DIAPHRAGM
ESOPHAGUS
LOWER COSTAL MARGIN
STOMACH
GALL BLADDER
COLON

HYPOSTHENIC
(35 PERCENT OF PATIENTS)

CHARACTERISTICS: THESE SUBJECTS ARE SIMILAR TO THE ASTHENIC. THE STOMACH, INTESTINES, AND GALL BLADDER ARE SITUATED HIGHER IN THE ABDOMEN.

177

DIGESTIVE SYSTEM

1. General

A. Functions

Receives and digests complex foods by:

1. Mechanical action

a. ____________________ or chewing

b. Muscle actions

(1) ________________

(2) ________________

2. Chemical reactions involving enzymes: organic compounds that aid chemical reactions without themselves being altered--catalysts.

EXAMPLES OF CHEMICAL REACTIONS

FOOD	ENZYME	AREA	CHEMICAL REACTION	A	S	P	PURPOSE
Carbohydrates	________ maltase	saliva, mouth duodenum, pancreatic juice	starches → dextrose	ABSORBED THRU WALL	SMALL INTESTINE	PROCESSED in LIVER	energy
________	____________ + (hydrochloric acid)	________ juice stomach	proteins → ________ acids				rebuild & repair tissue
______ (lipids)	______ + (bile, as emulsifier)	duodenum pancreatic juice	fats → fatty acids + glycerol				stored as neutral fat

B. Structures

1. Alimentary canal

168

2. Accessory organs

II. ANATOMY AND PHYSIOLOGY--ALIMENTARY TRACT

A. Mouth Region

1. Teeth

2. Tongue

3. Salivary glands

a. Parotid

b. Submaxillary

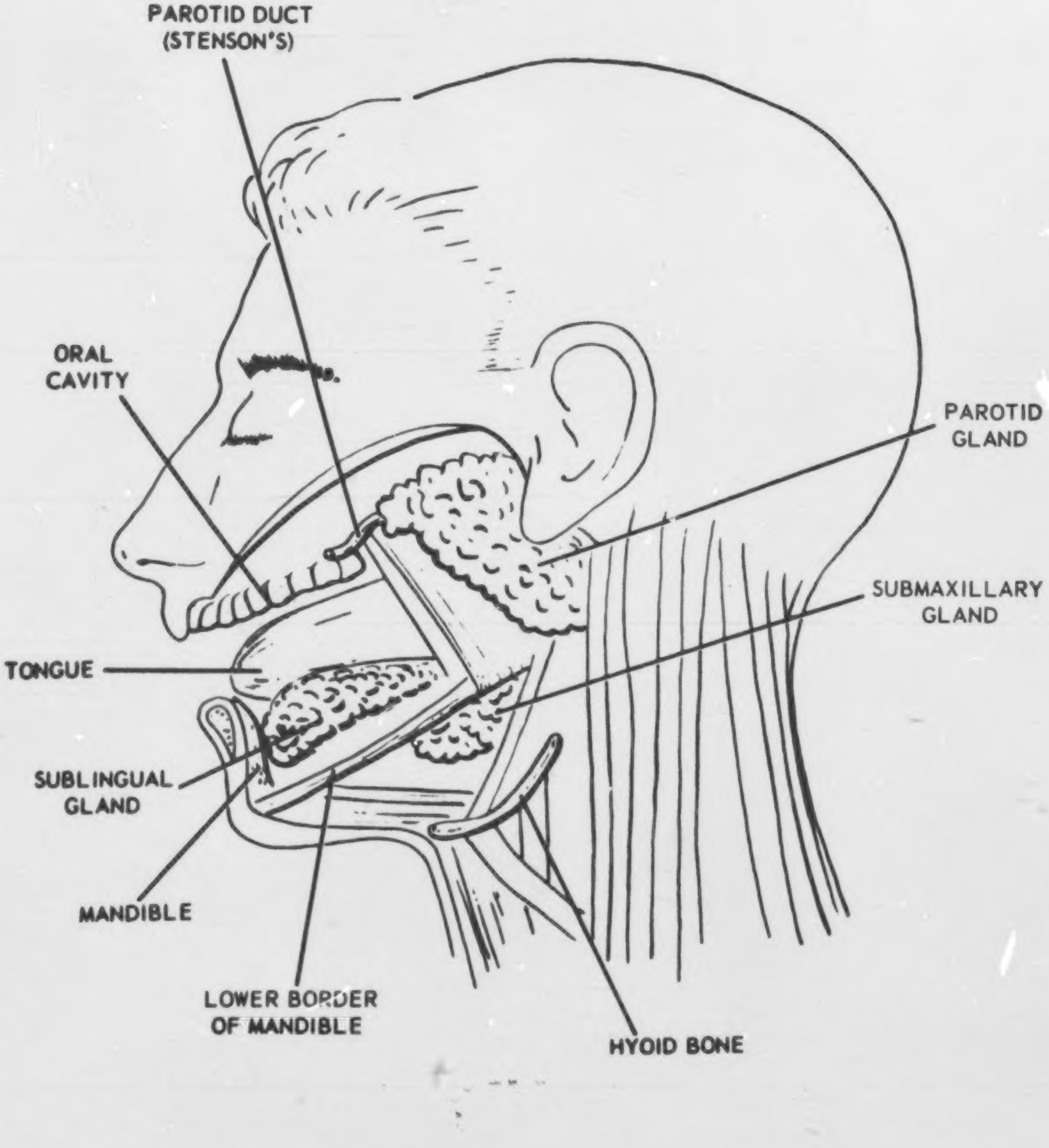
c. Sublingual

4. Saliva

a. Constituents

b. Functions

179


PAROTID DUCT
(STENSON'S)
ORAL CAVITY
PAROTID GLAND
SUBMAXILLARY GLAND
TONGUE
SUBLINGUAL GLAND
MANDIBLE
LOWER BORDER OF MANDIBLE
HYOID BONE

Salivary Glands

B. Pharynx
- NASOPHARYNX (air only) Respiratory System
- OROPHARYNX (air and food)
- LARYNGOPHARYNX (food only)

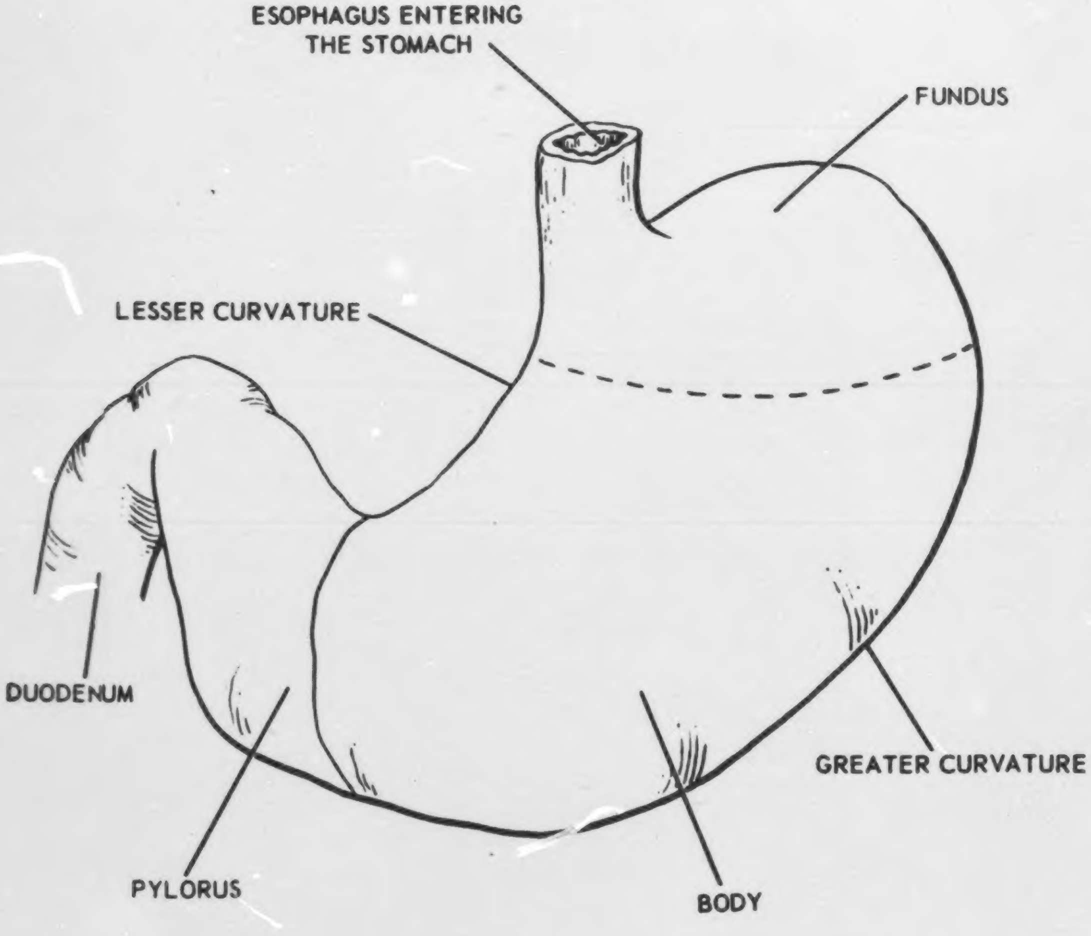
C. Esophagus

D. Stomach

1. Structures
   a. Openings

   b. Curvatures

   c. Regions of the stomach


ESOPHAGUS ENTERING THE STOMACH
FUNDUS
LESSER CURVATURE
DUODENUM
GREATER CURVATURE
PYLORUS
BODY

Stomach

172

d. Rugae

2. Functions of the Stomach

E. Small Intestine

1. Description

a. Duodenum

b. Jejunum

c. Ileum

183

2. Functions of:

   a. Duodenum

   b. Jejunum

   c. Ileum

F. Large Intestine

1. Structures

   a. Cecum

      Vermiform appendix

   b. Colon

   c. Rectum

   d. Anal canal

   e. Anus

174

2. Functions of the LARGE INTESTINE

III. ANATOMY AND PHYSIOLOGY--ACCESSORY ORGANS OF DIGESTION

A. Liver

1. Description

2. Functions (pertaining to radiographic procedures)

3. Location

B. Gall Bladder

1. Description

2. Location of the gall bladder

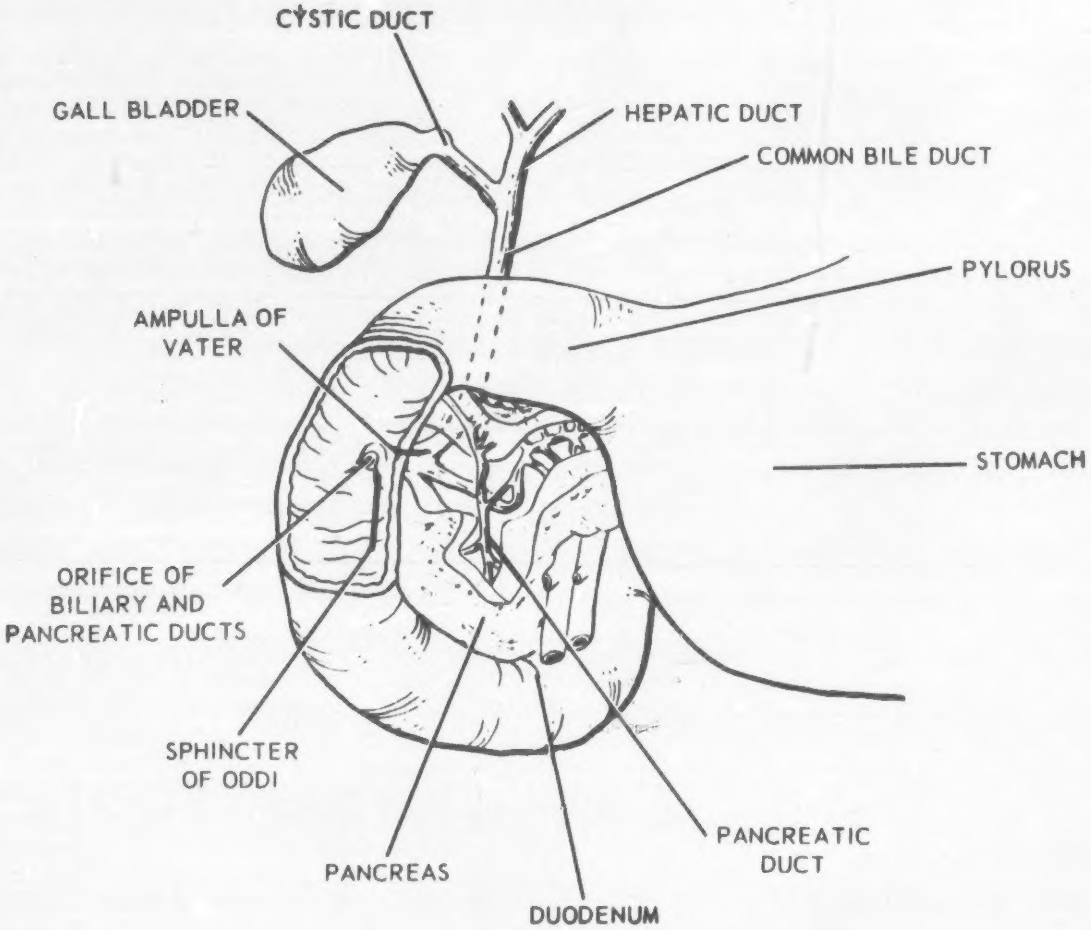
3. Functions

185

C. Pancreas

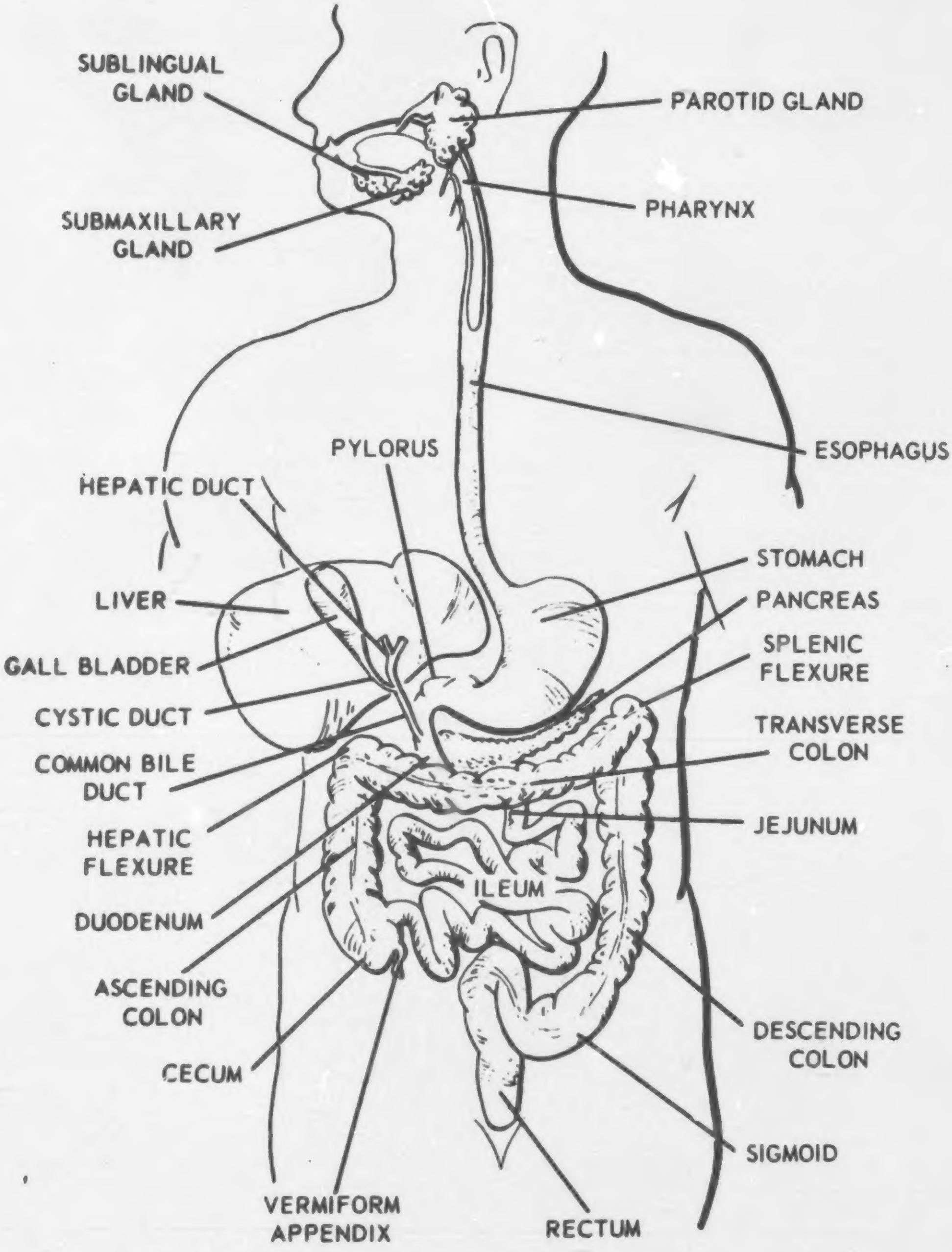
D. Biliary and Pancreatic Ducts

176


CYSTIC DUCT
GALL BLADDER
HEPATIC DUCT
COMMON BILE DUCT
PYLORUS
AMPULLA OF VATER
STOMACH
ORIFICE OF BILIARY AND PANCREATIC DUCTS
SPHINCTER OF ODDI
PANCREATIC DUCT
PANCREAS
DUODENUM

Biliary Duct System

187


SUBLINGUAL GLAND
PAROTID GLAND
SUBMAXILLARY GLAND
PHARYNX
ESOPHAGUS
PYLORUS
HEPATIC DUCT
STOMACH
LIVER
PANCREAS
GALL BLADDER
SPLENIC FLEXURE
CYSTIC DUCT
TRANSVERSE COLON
COMMON BILE DUCT
HEPATIC FLEXURE
JEJUNUM
ILEUM
DUODENUM
ASCENDING COLON
DESCENDING COLON
CECUM
SIGMOID
VERMIFORM APPENDIX
RECTUM

Digestive System

IV. RADIOGRAPHIC EXAMINATIONS

A. Sialography

B. Esophagram

C. Upper G.I. (Barium Meal)

D. Small Bowel

180

E. Barium Enema

F. Cholecystogram

191

G. Operative Choleangiogram (T-Tube)

182

CIRCULATORY SYSTEM

Divisions: CARDIOVASCULAR SYSTEM (heart and blood vessels), BLOOD (constituents), and LYMPHATIC SYSTEM (lymph vessels and lymph nodes)

I. CARDIOVASCULAR SYSTEM

A. Heart

1. Description of the organ

2. Location in the thorax

3. Structures

a. Chambers

b. Valves

193

3. The CARDIAC CYCLE

4. BLOOD PRESSURE

5. PULSE

B. Blood Vessels

1. Description of:

Artery

Vein

Capillary

a. List of major arteries and areas they serve

184

b. List of the principal veins of the body and the areas they serve

2. Functions of the CARDIOVASCULAR SYSTEM

II. BLOOD

A. Description (components and quantities)

1. Cells

195

2. Plasma

B. Function

III. LYMPHATIC SYSTEM

A. Structure

1. Vessels

2. Nodes

B. Function

1. Circulation

2. Other

IV. PATHOLOGICAL CONDITIONS

A. Aneurysm

B. Thrombus

C. Embolism

D. Arteriosclerosis

E. Atheriosclerosis

F. Septal Defect

G. Stenosis

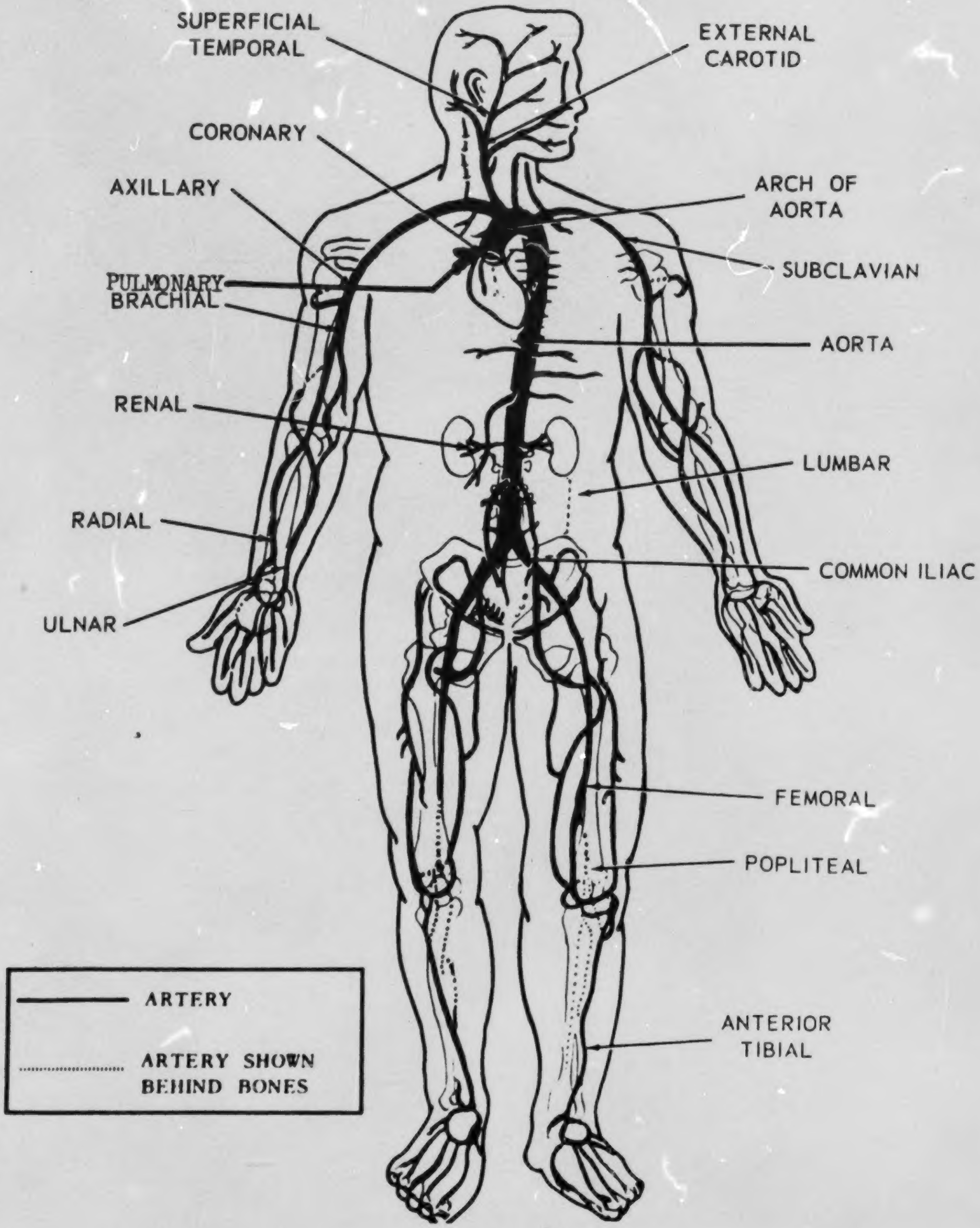
V. RADIOGRAPHIC EXAMINATIONS

A. Cardia Catheterization

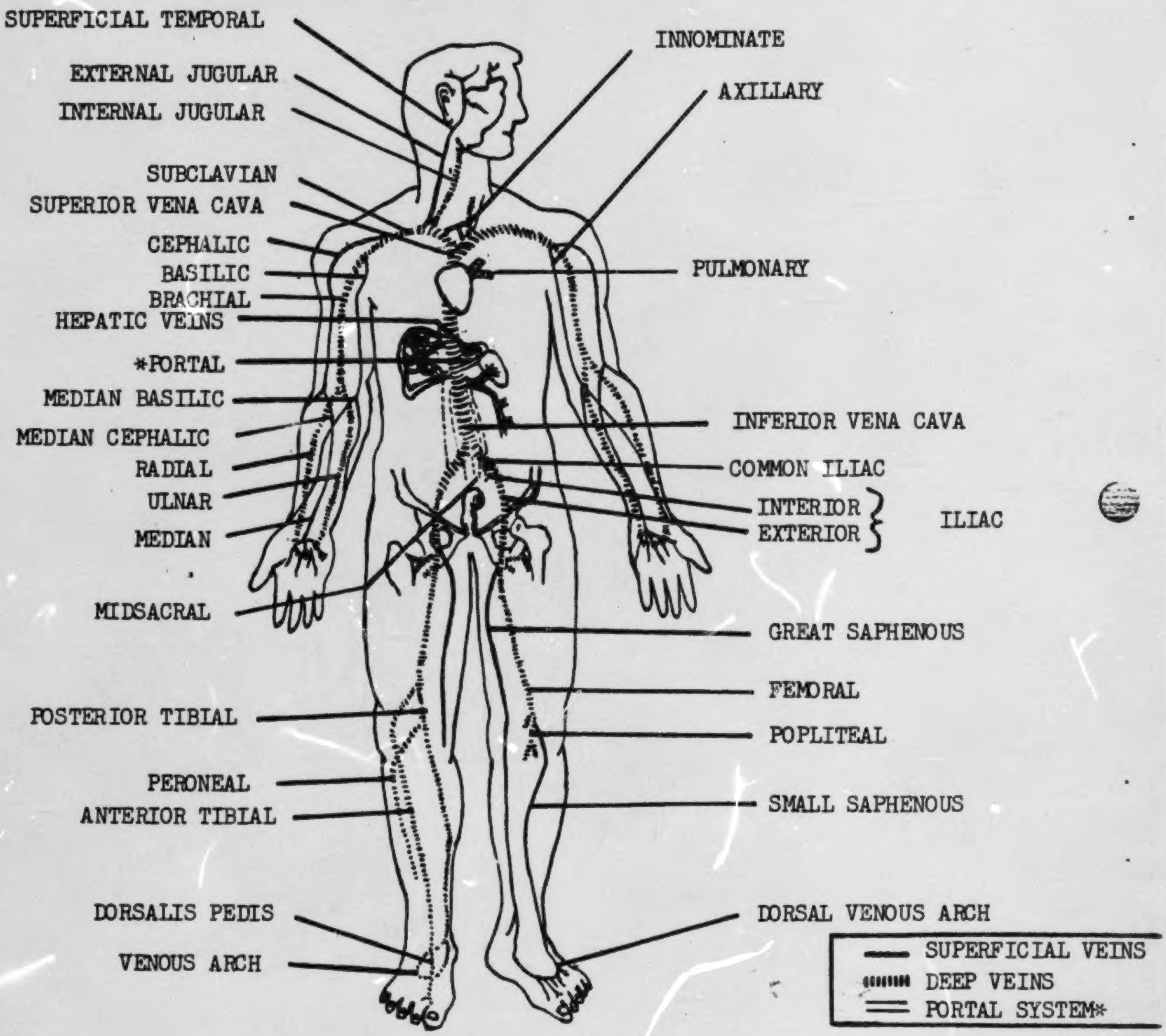
B. Arteriograms

C. Phlebogram

D. Lymphangiogram


SUPERFICIAL TEMPORAL
EXTERNAL CAROTID
CORONARY
AXILLARY
ARCH OF AORTA
SUBCLAVIAN
PULMONARY
BRACHIAL
AORTA
RENAL
LUMBAR
RADIAL
COMMON ILIAC
ULNAR
FEMORAL
POPLITEAL
ANTERIOR TIBIAL
ARTERY
ARTERY SHOWN BEHIND BONES

Circulatory System


SUPERFICIAL TEMPORAL
EXTERNAL JUGULAR
INTERNAL JUGULAR
SUBCLAVIAN
SUPERIOR VENA CAVA
CEPHALIC
BASILIC
BRACHIAL
HEPATIC VEINS
*PORTAL
MEDIAN BASILIC
MEDIAN CEPHALIC
RADIAL
ULNAR
MEDIAN
MIDSACRAL
POSTERIOR TIBIAL
PERONEAL
ANTERIOR TIBIAL
DORSALIS PEDIS
VENOUS ARCH
INNOMINATE
AXILLARY
PULMONARY
INFERIOR VENA CAVA
COMMON ILIAC
INTERIOR
EXTERIOR
ILIAC
GREAT SAPHENOUS
FEMORAL
POPLITEAL
SMALL SAPHENOUS
DORSAL VENOUS ARCH
SUPERFICIAL VEINS
DEEP VEINS
PORTAL SYSTEM*

PRINCIPAL VEINS

Osteology of the Skull

I. BONES OF THE CRANIUM

A. Frontal

B. Parietal

C. Temporal

D. Occipital

E. Sphenoid

194

F. ETHMOID

II. SUTURES

III. TERMS

205

195

II. SUTURES

196

III. TERMS

207

Osteology of the Skull

I. BONES OF THE FACE

A. Nasal

B. Lacrimal

C. Zygoma

D. Maxillary

E. Palatine

F. Inferior Nasal Concha

G. Vomer

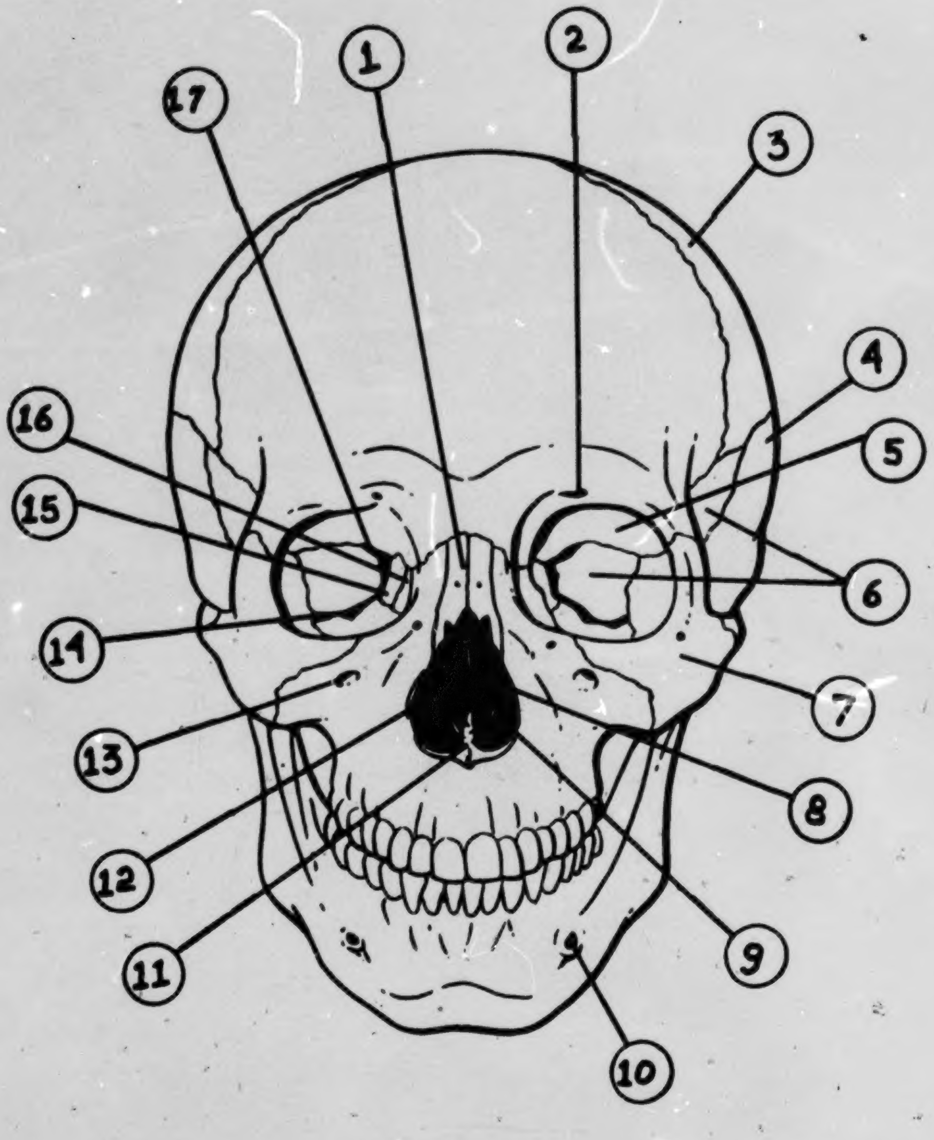
H. Mandible

200

II. TERMS

211

201


17
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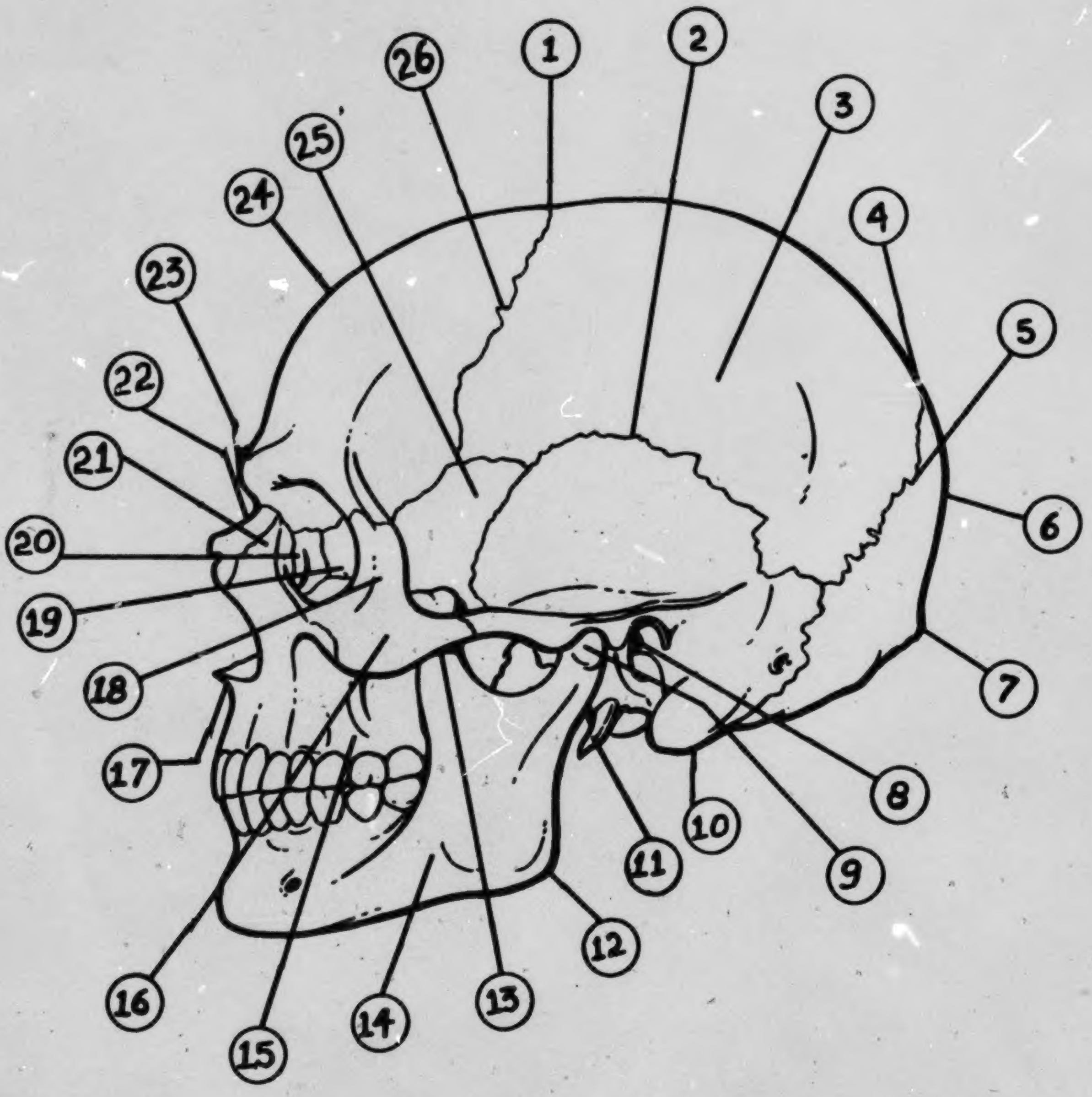
8
12
9
11
10

SKULL

(Anterior View)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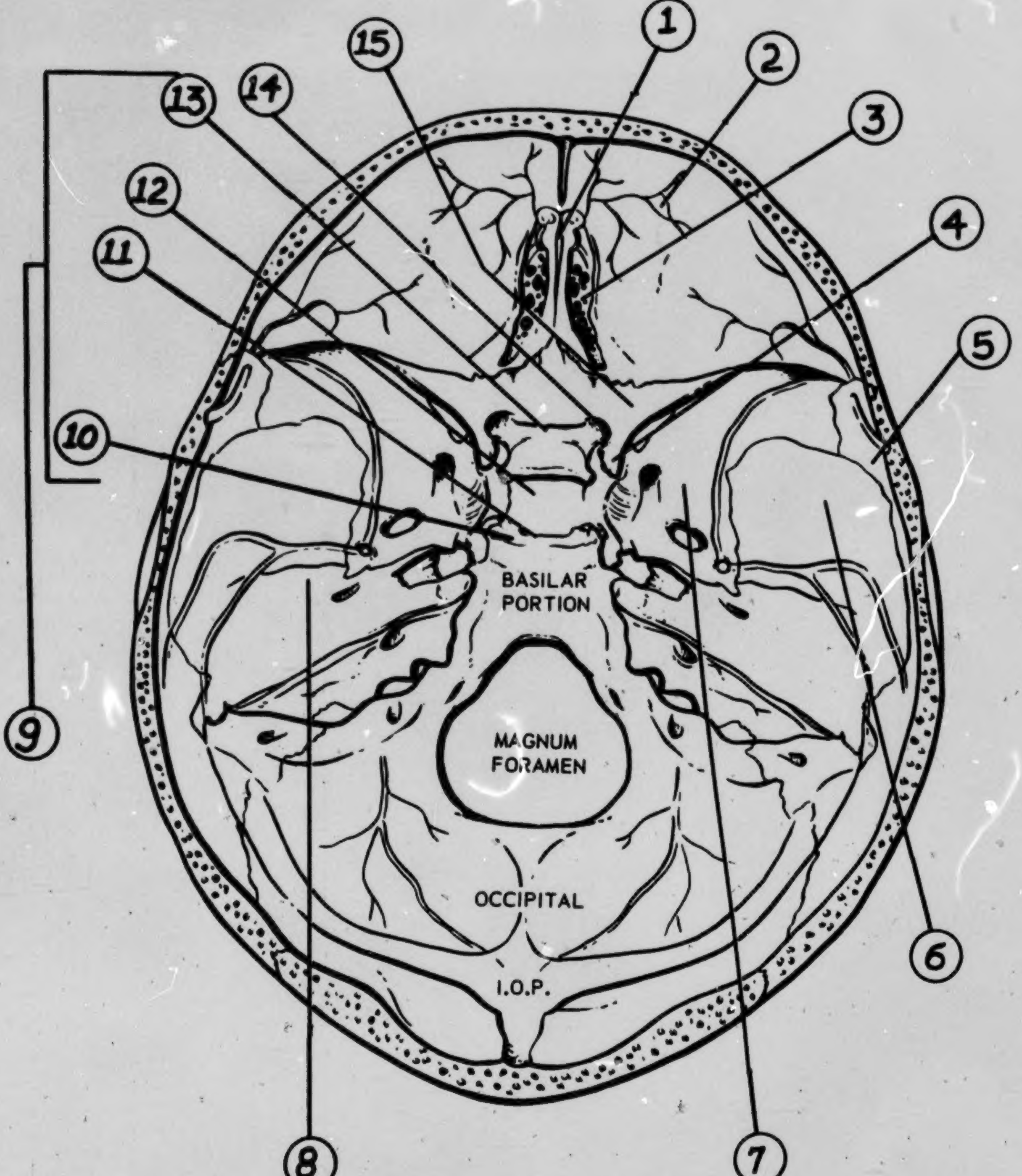
26

SKULL 213

(Lateral View)

203



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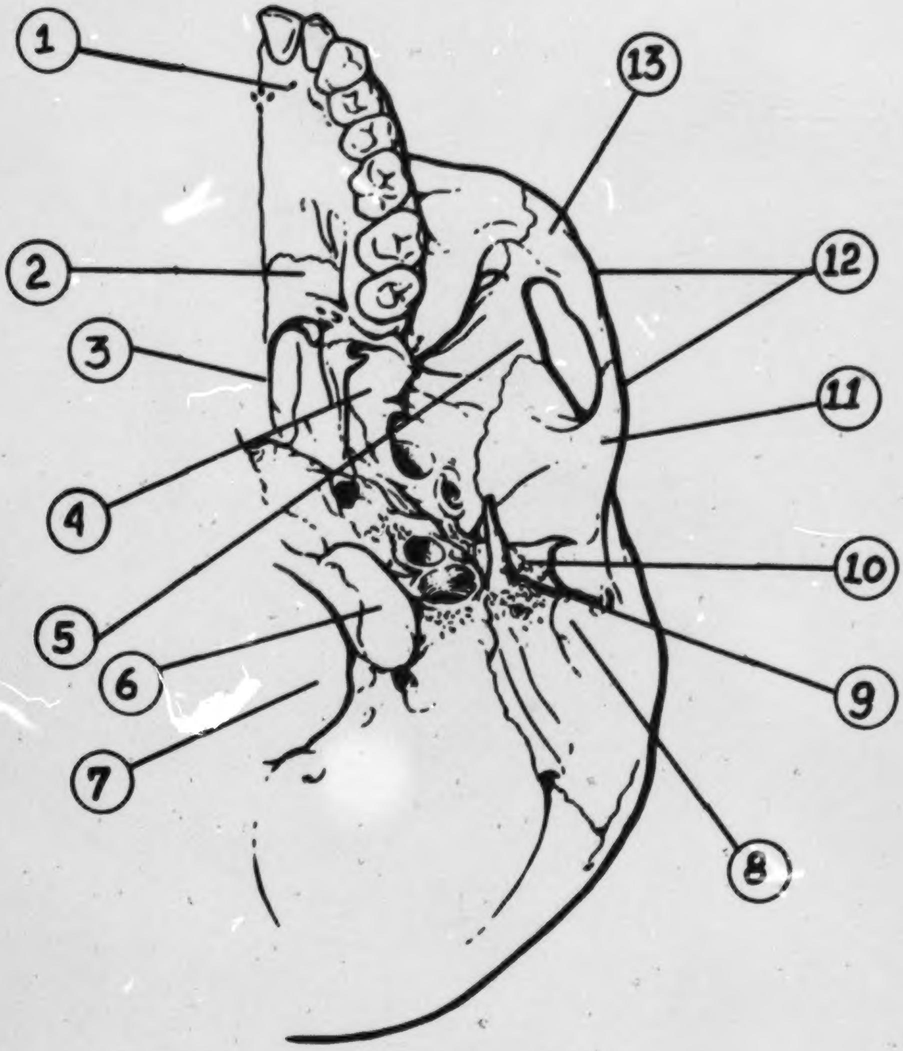
14
15
BASILAR PORTION
MAGNUM FORAMEN
OCCIPITAL
I.O.P.

SKULL FROM ABOVE

204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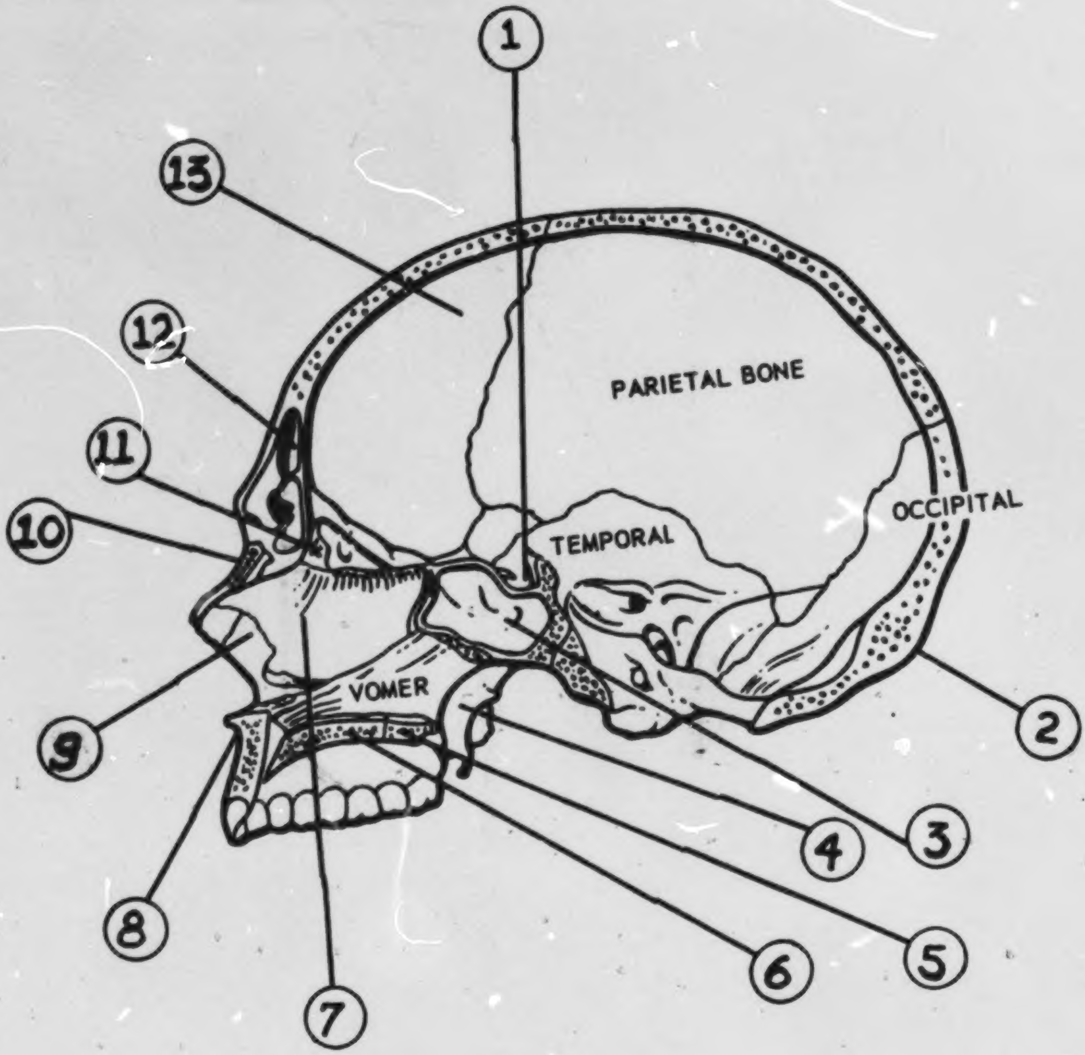
215

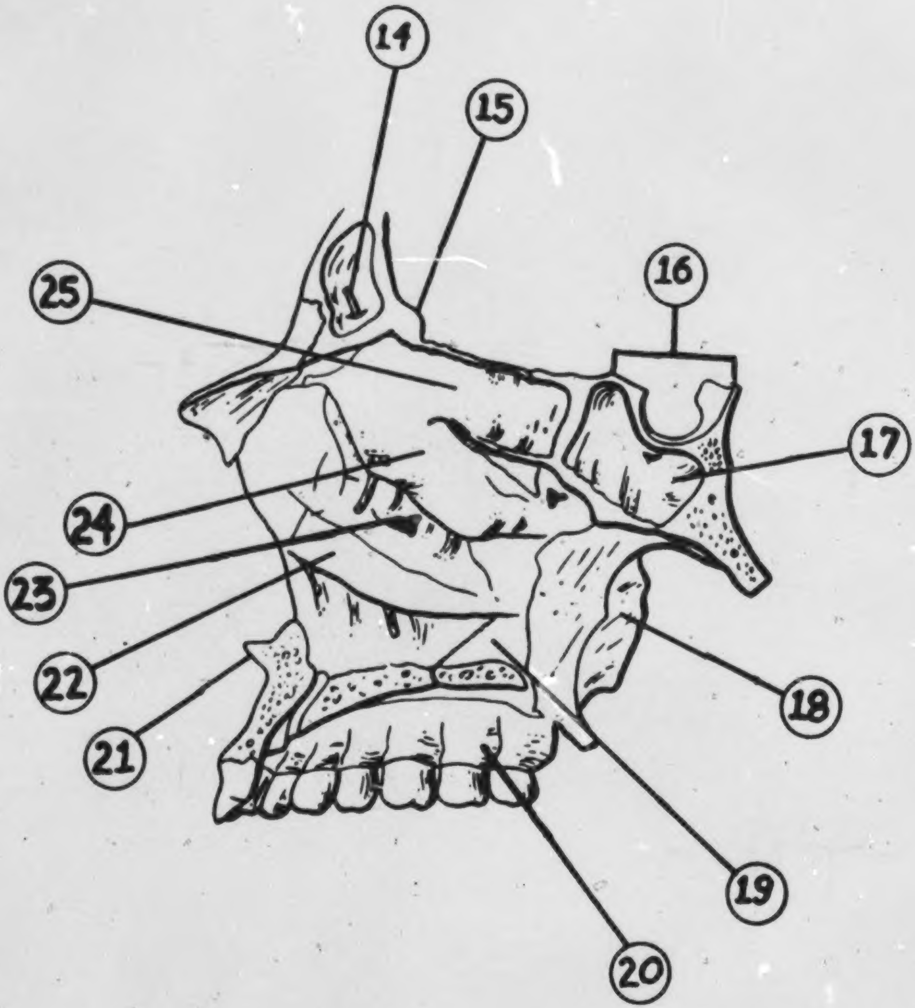
INFERIOR VIEW--MANDIBLE REMOVED

205


1
13
12
11
10
9
8
7
6
5
4
3
2
PARIETAL BONE
OCCIPITAL
TEMPORAL
VOMER

SAGITTAL SECTION OF SKULL

SAGITTAL SECTION (Continued)


14
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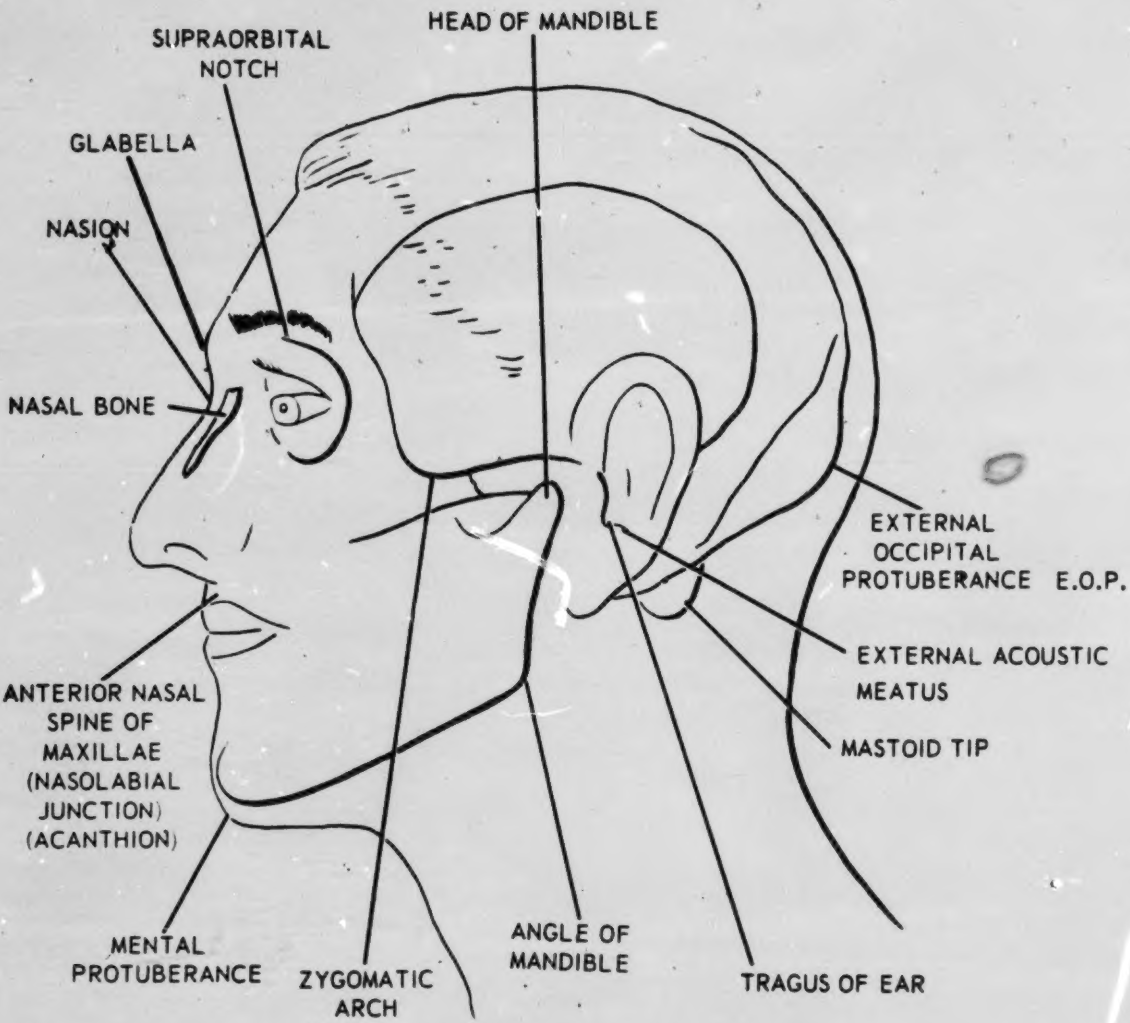
19
20

LATERAL WALL OF NASAL CAVITY

Palpation Points of the Skull

Palpation Points of the Skull


HEAD OF MANDIBLE
SUPRAORBITAL NOTCH
GLABELLA
NASION
NASAL BONE
EXTERNAL OCCIPITAL PROTUBERANCE E.O.P.
EXTERNAL ACOUSTIC MEATUS
MASTOID TIP
ANTERIOR NASAL SPINE OF MAXILLAE (NASOLABIAL JUNCTION) (ACANTHION)
MENTAL PROTUBERANCE
ZYGOMATIC ARCH
ANGLE OF MANDIBLE
TRAGUS OF EAR

LATERAL ASPECT

209

ANTERIOR VIEW OF THE SKULL

1. NASAL BONES
2. SUPRAORBITAL NOTCH--FRONTAL
3. PARIETAL BONE
4. SQUAMA--TEMPORAL
5. ORBITAL PLATE--FRONTAL
6. GREATER WING OF THE SPHENOID
7. ZYGOMA OR MALAR
8. MIDDLE AND SUPERIOR NASAL CONCHA--ETHMOID
9. INFERIOR NASAL CONCHA
10. MENTAL FORAMEN--MANDIBLE
11. VOMER BONE
12. PERPENDICULAR PLATE--ETHMOID
13. INFRAORBITAL FORAMEN--MAXILLA
14. INFERIOR ORBITAL FISSURE
15. ETHMOID BONE
16. LACRIMAL BONE
17. SUPERIOR, ORBITAL FISSURE

LATERAL VIEW OF THE SKULL

1. BREGMA
2. SQUAMOSAL SUTURE
3. PARIETAL BONE
4. LAMBDA
5. LAMBDOIDAL SUTURE
6. SQUAMA--OCCIPITAL
7. EXTERNAL OCCIPITAL PROTUBERANCE--OCCIPITAL
8. EXTERNAL AUDITORY MEATUS--TEMPORAL
9. CONDYLOID PROCESS--MANDIBLE
10. MASTOID TIP--TEMPORAL
11. STYLOID PROCESS--TEMPORAL
12. ANGLE--MANDIBLE
13. CORONOID PROCESS--MANDIBLE
14. BODY--MANDIBLE
15. ALVEOLAR RIDGE--MAXILLA
16. ZYGOMA OR MALAR
17. ANTERIOR NASAL SPINE--MAXILLA
18. FRONTAL PROCESS--MALAR
19. ETHMOID BONE
20. LACRIMAL BONE
21. FRONTAL PROCESS--MAXILLA
22. NASAL BONE
23. GLABELLA--FRONTAL
24. SQUAMA--FRONTAL
25. GREATER WING OF THE SPHENOID
26. CORONAL SUTURE

THE SKULL FROM ABOVE

1. CRISTA GALLI--ETHMOID
2. ORBITAL PLATE--FRONTAL
3. CRIBRIFORM PLATE--ETHMOID
4. ANTERIOR CLINOID PROCESS--SPHENOID
5. PARIETAL
6. SQUAMA--TEMPORAL
7. GREATER WING OF THE SPHENOID
8. PETROUS PORTION--TEMPORAL
9. SELLA TURCICA--SPHENOID
10. POSTERIOR CLINOID--SPHENOID
11. DORSUM SELLAE--SPHENOID
12. PITUITARY FOSSA--SPHENOID
13. OPTIC GROOVE--SPHENOID
14. OPTIC FORAMEN--SPHENOID
15. LESSER WING--SPHENOID

INFERIOR VIEW--MANDIBLE REMOVED

1. PALATINE PROCESS--MAXILLA
2. PALATINE BONE
3. VOMER BONE
4. PTERYGOID PROCESS--SPHENOID
5. GREATER WING OF THE SPHENOID
6. OCCIPITAL CONDYLE--OCCIPITAL
7. FORAMEN MAGNUM--OCCIPITAL
8. MASTOID TIP--TEMPORAL
9. STYLOID PROCESS--TEMPORAL
10. GLENOID FOSSA--TEMPORAL
11. ZYGOMATIC PROCESS--TEMPORAL
12. ZYGOMATIC ARCH
13. TEMPORAL PROCESS--ZYGOMA

SAGITTAL SECTION OF THE SKULL

1. PITUITARY FOSSA--SPHENOID
2. EXTERNAL OCCIPITAL PROTUBERANCE--OCCIPITAL
3. SPHENOID SINUS
4. PTERYGOID PROCESS--SPHENOID
5. PALATINE BONE
6. PALATINE PROCESS--MAXILLA
7. PERPENDICULAR PLATE--ETHMOID
8. ANTERIOR NASAL SPINE--MAXILLA
9. FRONTAL PROCESS--MAXILLA
10. NASAL BONE
11. CRISTA GALLI--ETHMOID
12. FRONTAL SINUS
13. SQUAMA--FRONTAL
14. PROBE IN FRONTAL SINUSES (emerging in the nasal chamber)
15. CRISTA GALLI--ETHMOID
16. SELLA TURCICA--SPHENOID
17. SPHENOID SINUS
18. PTERYGOID PROCESS--SPHENOID
19. PALATINE BONE
20. ALVEOLAR RIDGE--MAXILLA
21. ANTERIOR NASAL SPINE--MAXILLA
22. INFERIOR NASAL CONCHA
23. Opening of the MAXILLARY SINUSES into nasal chamber
24. MIDDLE NASAL CONCHA--ETHMOID
25. SUPERIOR NASAL CONCHA--ETHMOID

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214

ACADEMY OF HEALTH SCIENCES, US ARMY
MEDICINE AND SURGERY DIVISION
X-RAY BRANCH

PI 38-100-016-1
095

TWO-WAY HEAD ALIGNMENTS

SECTION I - ANATOMICAL LANDMARKS OF THE SKULL

226

215

PI 38-100-016-1
095

TWO-WAY HEAD ALIGNMENT

Section I - ANATOMICAL LANDMARKS OF THE SKULL

This is the first section of a 3-section program on two-way head alignments. This section deals exclusively with the anatomical landmarks used to determine reference lines and reference planes in the skull.

The objectives of Section I are to introduce and/or review the anatomical landmarks of the skull and to insure that you have a working knowledge of the terms to be used in Sections II and III.

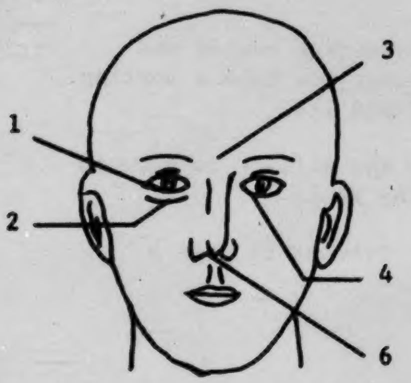
Upon completion of Section I, you will have the ability to proceed to Section II dealing with lines and planes of the skull.

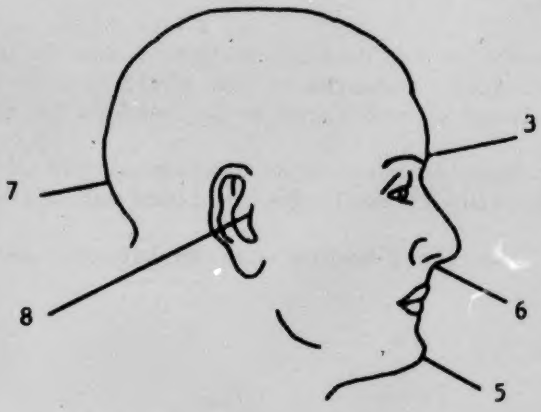
Section I begins with an information page. Proceed to page 3.

227

INFORMATION PAGE

Familiarize yourself with all the information given below.





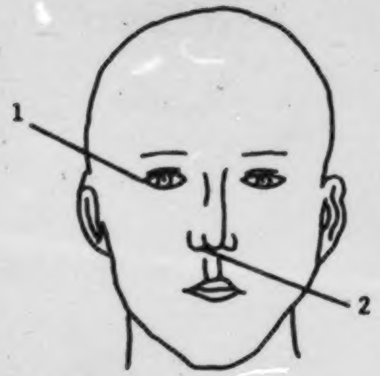
1. External Canthus of the Eye - Outer (Lateral) corner of the eye.
2. Infraorbital Ridge - Lower border or ridge of the orbit.
3. Glabella - Anterior protuberance of the frontal bone (between the eyebrows).
4. Internal Canthus of the Eye - Inner (medial) corner of the eye.
5. Mental Protuberance - the point of the chin.
6. Acanthion - Where the nose and the upper lip meet (also called the nasolabial junction).
7. External Occipital Protuberance (EOP) - The protuberance at the base of the skull on the outer or external surface of the occipital bone.
8. External Auditory Meatus (EAM) - The external opening or the hole in the ear.

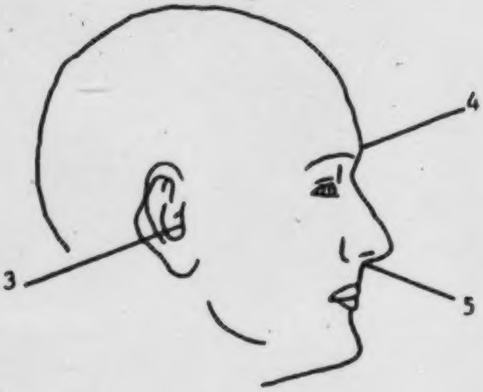
After you have familiarized yourself with all the above information, turn to page 4.

NOTE: All answers will be given. If, at any time you do not understand the correct answer, feel free to return to this page.

Fill in all of the blanks that you can on the following pages.

Continue on page 5 and begin to fill in the blanks.





1. ______________________

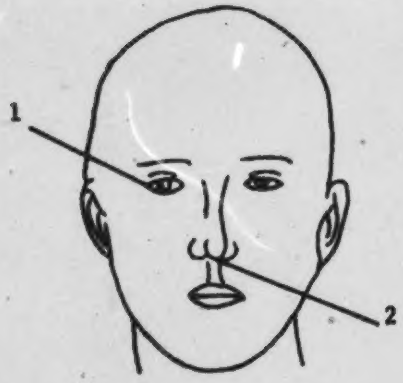
2. ______________________

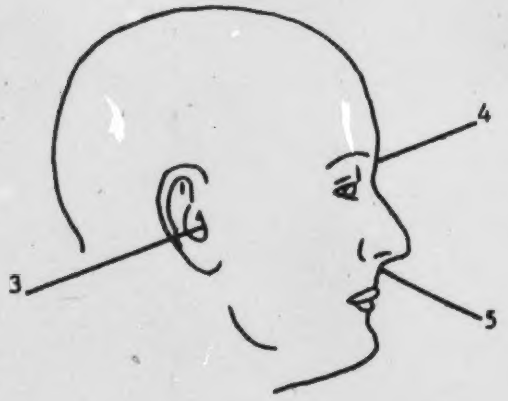
3. ______________________

4. ______________________

5. ______________________

When completed, turn to page 6 for correct answers.





1. External Canthus

*2. Acanthion

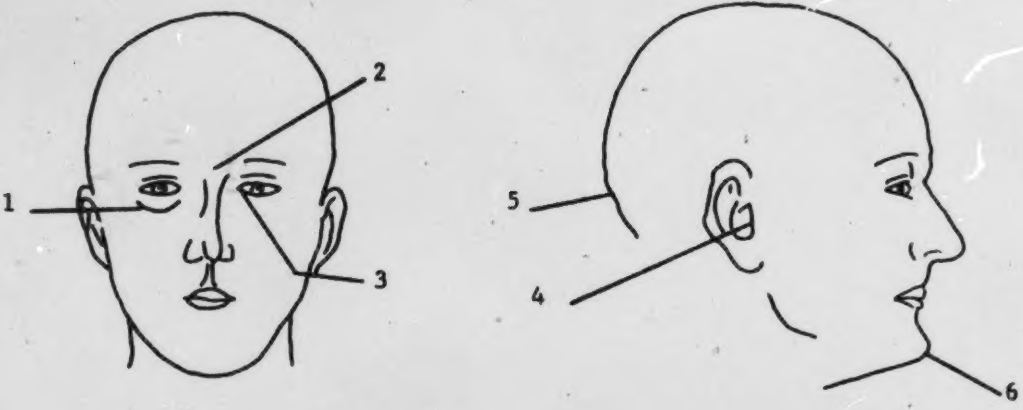
3. External Auditory Meatus

4. Glabella

5. Acanthion

*The terms nasolabial junction and anterior nasal spine are also correct, but, for the remainder of this program, the term acanthion will be used.

If you have an INCORRECT answer, cross it out and write the correct response above it. Then, turn to page 7.



1. ______________________

2. ______________________

3. ______________________

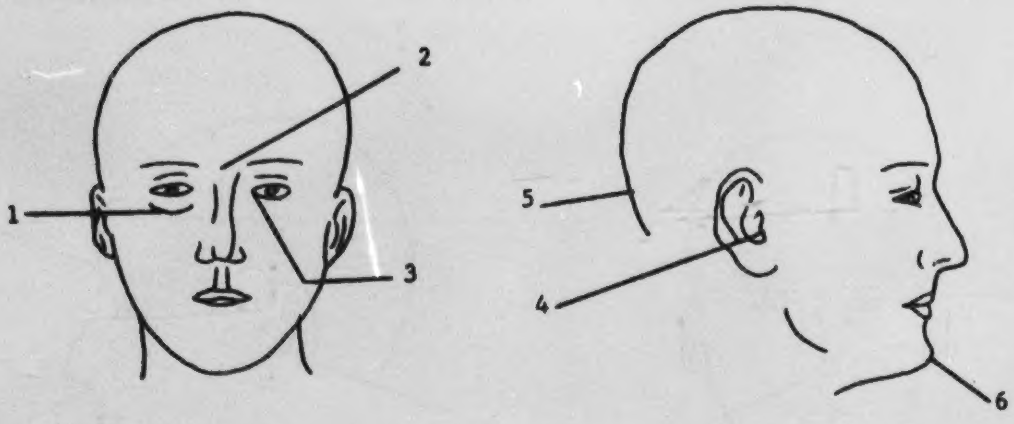
4. ______________________

5. ______________________

6. ______________________

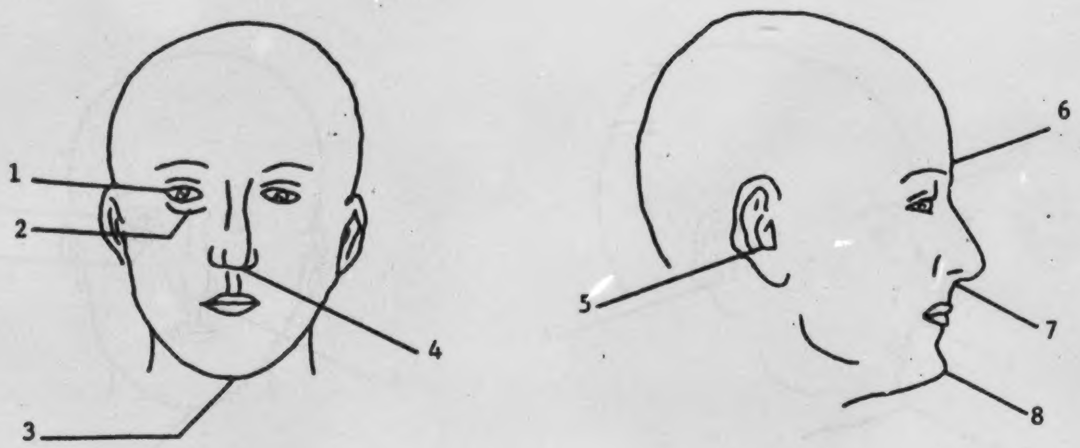
When completed, turn to page 8 for correct answers.

221



1. Infraorbital Ridge
2. Glabella
3. Internal Canthus
4. External Auditory Meatus
5. External Occipital Protuberance
6. Mental Protuberance

If you have an INCORRECT answer, cross it out and write the correct response above it. Then, turn to page 9.



1. ______________________

2. ______________________

3. ______________________

4. ______________________

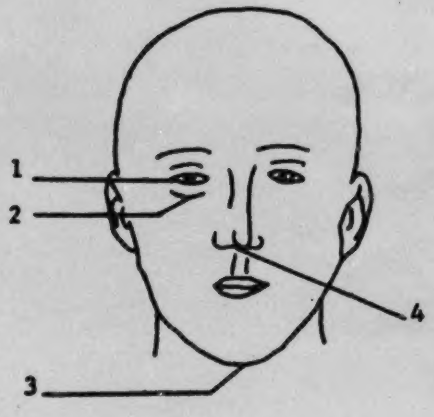
5. ______________________

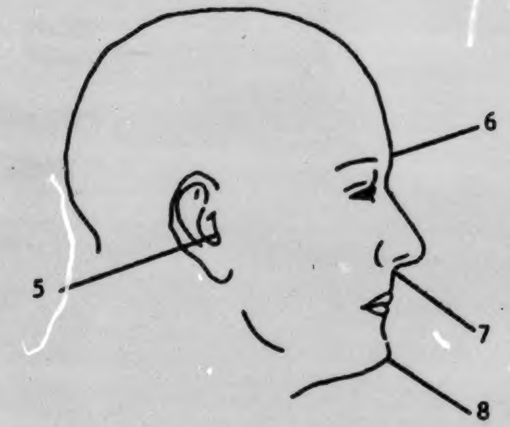
6. ______________________

7. ______________________

8. ______________________

When completed, turn to page 10 for correct answers.

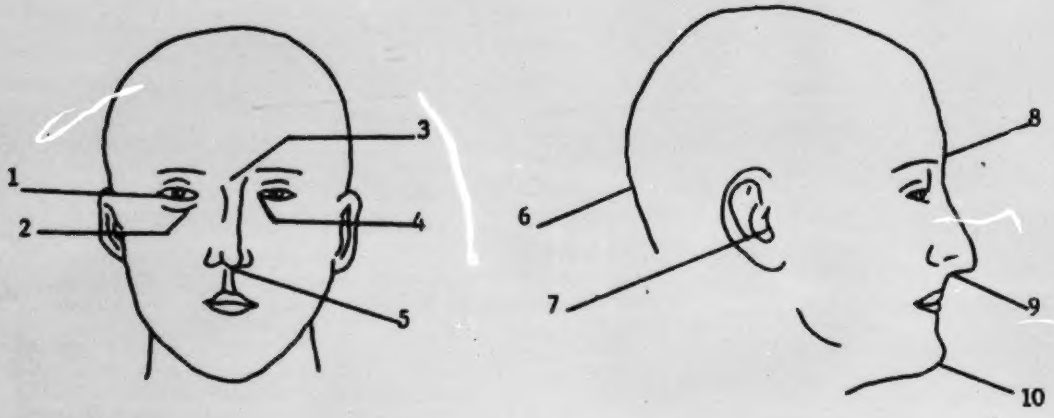




1. External Canthus
2. Infraorbital Ridge
3. Mental Protuberance
4. Acanthion
5. External Auditory Meatus
6. Glabella
7. Acanthion
8. Mental Protuberance

If you have an INCORRECT answer, cross it out and write the correct response above it. Then, turn to page 11.

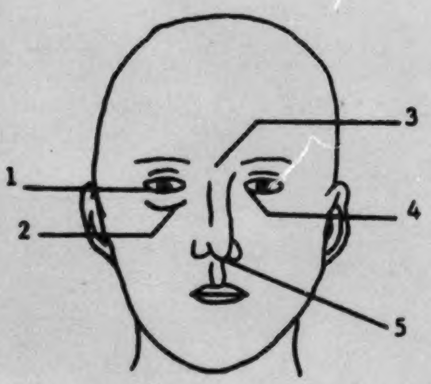
2224

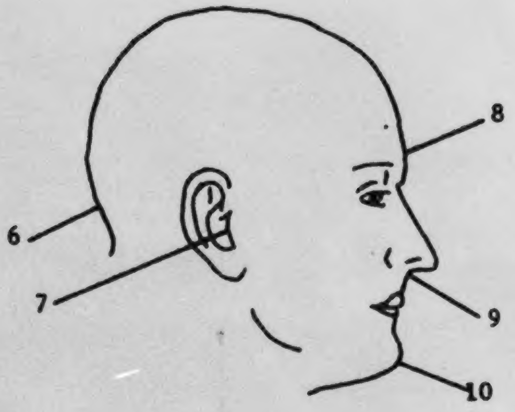

1
2
3
4
5
6
7
8
9
10

1. ______________________
2. ______________________
3. ______________________
4. ______________________
5. ______________________
6. ______________________
7. ______________________
8. ______________________
9. ______________________
10. ______________________

When completed, turn to page 12 for correct answers.

236





1. External Canthus
2. Infraorbital Ridge
3. Glabella
4. Internal Canthus
5. Acanthion
6. External Occipital Protuberance
7. External Auditory Meatus
8. Glabella
9. Acanthion
10. Mental Protuberance

If you have an INCORRECT answer, cross it out and write the correct response above. Then, turn to page 13.

You have now completed Section I and have attained a working knowledge of the anatomical landmarks of the skull. At this point, we will advance to Section II. In Section II, you will use these anatomical landmarks to find specific lines and planes. These lines and planes will be used for positioning the skull.

PI 38-100-016-2
095

TWO-WAY HEAD ALIGNMENTS

SECTION II - LINES AND PLANES OF THE SKULL

Now that you have completed the first section of the programmed instruction on two-way head alignments, you are ready to proceed with Section II. Section II is designed to teach you the lines and planes of the skull.

This is a sample of how to use the program. Information will be presented to you in segments called frames. Each frame is numbered and requires you to answer a question. Place your scratch paper on the line below the frame and read the frame. Answer the question and write the answer on the answer sheet in the blank by that frame number. Move your scratch paper down and check your answer.

EXAMPLE FRAMES

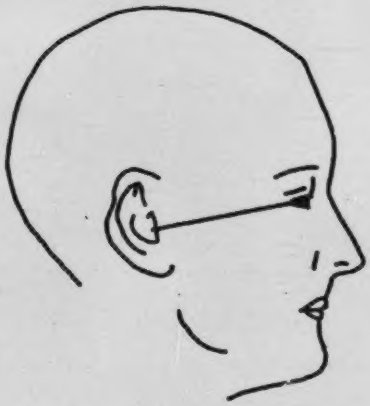
1. Read the frames.
2. Answer the question.
3. Write answers on answer sheet.
4. Check answer and proceed to next frame.

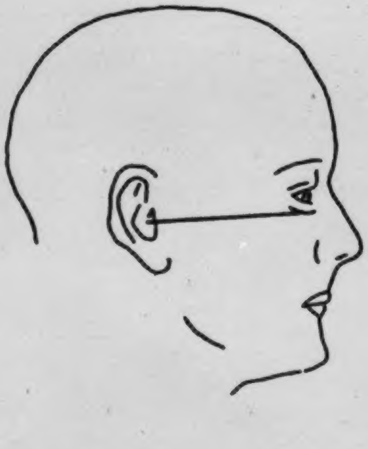
	1. There are ______ bones in the wrist.
Answer to Frame 1: 8	2. Which of the following is in the proximal row of carpals? Navicular, Hamate
Answer to Frame 2: Navicular	3. The hamulus process is found on the H ______ bone.
Answer to Frame 3: Hamate	

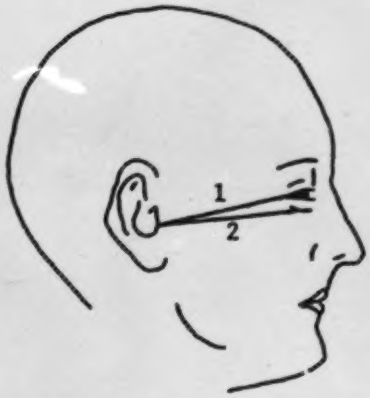
THIS IS NOT A TEST - IT IS A NEW METHOD OF LEARNING.

All the answers are given but you will probably do better to write down your answer on your answer sheet before checking to see if you are correct. If you find you answers is NOT the same as the answer in the program, find your error and when you see what you did wrong, write your new correct answer on the answer sheet before proceeding. IF YOU MAKE AN ERROR, DO NOT ERASE YOUR ORIGINAL ANSWER. JUST LINE IT OUT AND INSERT THE CORRECT ANSWER,

	1. The outer corner of the eye is known as the ____________ ____________ of the eye.
1. External canthus	2. The external opening of the ear is known as the ____________ ____________ ____________.
2. External auditory meatus	3. One of the lines we use in X-ray is the ORBITAL MEATAL LINE. This is a line connecting the external auditory meatus and the external canthus of the eye. The line from the external auditory meatus to the external canthus of the eye is the ____________ ____________ line.
3. Orbital Meatal Line	4. The line connecting the external canthus of the eye and the external auditory meatus is the ____________ ____________ Line.
4. Orbital Meatal Line	5. The line frequently used in skull radiography to obtain proper alignment, extending from the external canthus of the eye to the external auditory meatus, is known as the ____________ ____________ Line.
5. Orbital Meatal Line	6. The Orbital Meatal Line is important radiographically and is used in positioning various views of the skull. This line extends from the ____________ ____________ of the eye to the ____________ ____________ ____________.

6. External canthus External auditory meatus	7.  This drawing illustrates the ______________ __________________ Line.
7. Orbital Meatal Line	8. The lower border of the orbit is known as the ______________-______________ ridge.
8. Infra-orbital ridge	9. The external opening of the ear is known as the __________ ___________ ___________.
9. External auditory meatus	10. We have learned that the Orbital Meatal Line is one of the reference lines used in positioning the skull. Another line used in skull radiography is INFRA-ORBITAL MEATAL LINE. Infra-orbital meatal line extends from the external auditory meatus to the infra-orbital ridge. The line extending from the external auditory meatus to the infra-orbital ridge is ______________ _________________ ____________________ Line.
10. Infra-Orbital Meatal Line	11. Of the two lines that we have talked about, the one connecting the external auditory meatus and the infra-orbital ridge is known as _________ ___________ ___________Line.

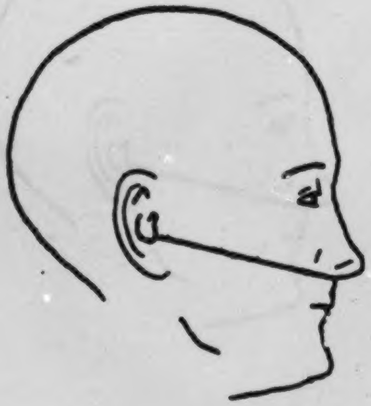
11. Infra-Orbital Meatal Line	12. The line connecting the external auditory meatus and the infra-orbital ridge is ______ ______ ______ Line.
12. Infra-Orbital Meatal Line	13. Infra-orbital Meatal Line is the line extending from the ______ ______ meatus to the ______-______ridge.
13. External auditory meatus Infra-orbital ridge	14. The Orbital Meatal Line extends from the external auditory meatus to the ______ ______ of the eye. The difference in infra-orbital meatal line and the orbital meatal line is that infra-orbital meatal line extends to the ______-______ ______.
14. External canthus Infra-orbital ridge	15.  This drawing illustrates the ______ ______ ______ Line.

15. Infra-Orbital Meatal Line	16.  In this drawing, line (1) represents the __________ ______ Line, line (2) represents the ______ ______ ______ Line. The angle formed by these two lines is approximately 8°.
16. (1) Orbital Meatal Line (2) Infra-Orbital Meatal Line	17. Another term used to refer to the nasolabial junction is the __________.
17. Acanthion	18. The common anatomical landmark used for both the Orbital Meatal Line and Infra-Orbital Meatal Line will also be used for our next line. This point is the __________ ______ __________.

18. External auditory meatus	19. The line connecting the external auditory meatus and the acanthion is the ACANTHIO-MEATAL LINE. The line connecting the external auditory meatus and the acanthion is the ___________-_____________ Line.
19. Acanthio-Meatal Line	20. If we were to draw a line from the acanthion to the external auditory meatus, this would be the A_____________-M___________Line.
20. Acanthio-Meatal Line	21. If we were to draw a line from the external auditory meatus to the external canthus of the eye, this would be the _______________ _______________ Line.
21. Orbital Meatal Line	22. If we were to start with the Orbital Meatal Line and move only one end of this line from the external canthus of the eye downward to the acanthion, the resulting line would be called the ___________-___________ Line.
22. Acanthio-Meatal Line	23. The Acanthio-Meatal Line extends from the _____________ to the external _____________ ___________________.
23. Acanthion External auditory meatus	24. The line extending from the acanthion to the external auditory meatus is the __________-________________ Line.

24. **Acanthio-Meatal Line**

25.

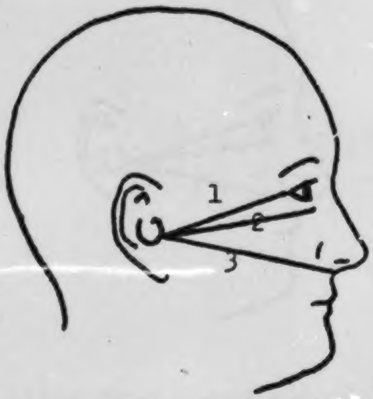


This line represents the __________ -
__________ Line.

---

25. **Acanthio-Meatal Line**

26.

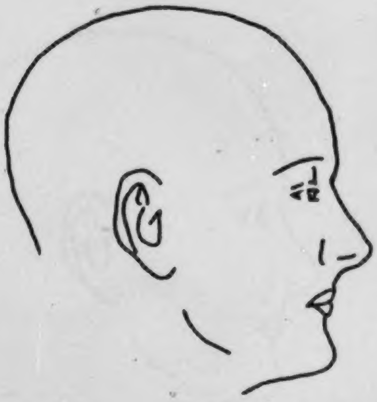


The three lines represented here are:

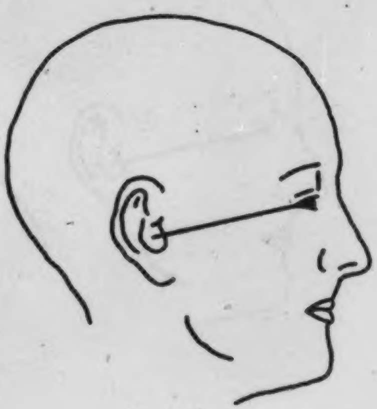
(1) __________ __________ Line

(2) _____-__________ ________ Line

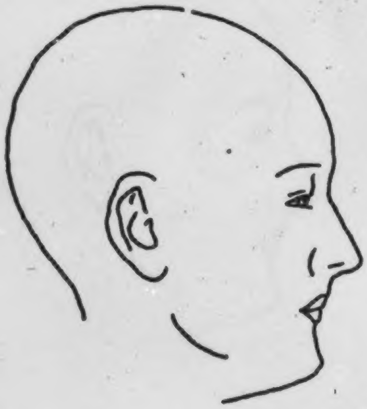
(3) __________-_____ ______ Line

26. (1) Orbital Meatal Line (2) Infra-Orbital Meatal Line (3) Acanthio-Meatal Line	27. A line connecting the external auditory meatus and the intra-orbital ridge is the ______________-______________ Line.
27. Infra-Orbital Meatal Line	28. A line connecting the external auditory meatus and the acanthion is the ______________-______________ Line.
28. Acanthio-Meatal Line	29. A line connecting the external auditory meatus and the external canthus of the eye is the ______________ ______________ Line.
29. Orbital Meatal Line	30.  Draw a line representing the Orbital Meatal Line.

30.

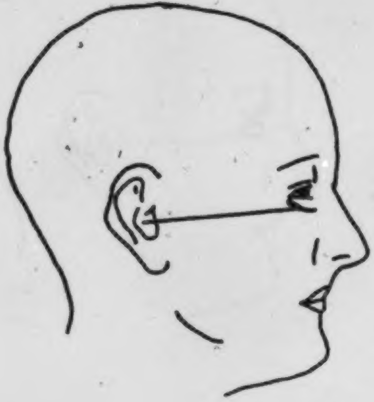


31.

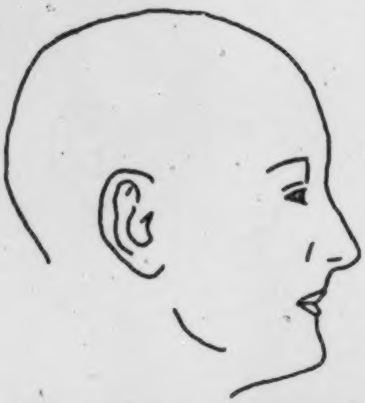


Draw a line representing the Infra-Orbital Meatal Line.

31.

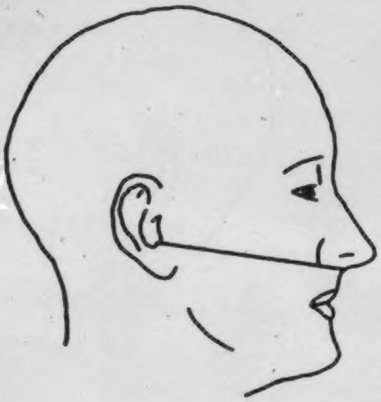


32.



Draw a line representing the Acanthio-Meatal Line.

32.



33. We have talked about three lines used to properly align the skull. Along with these lines, there are two planes that we must consider. The first of these is the mid-sagittal plane. The midsagittal plane divides the body into right and left halves. The plane that divides the body into right and left halves is the

____________________ plane.

---

33. **Midsagittal** plane

34. In the skull, the midsaggital plane is cut through the mental protuberance, glabella, and the external occipital protuberance. The plane through these points would divide the skull into right and left halves and therefore, would be called the

____________________ plane.

---

34. **Midsagittal** plane

35. The plane through the mental protuberance, glabella, and the external occipital protuberance

is the mid______________ plane of the skull.

---

35. **Midsagittal** plane

36. The midsagittal plane of the skull is a plane cut through the

_____________ protuberance,

_____________, and the

__________ ______________

protuberance.

237

36. Mental protuberance

Glabella

External occipital protuberance

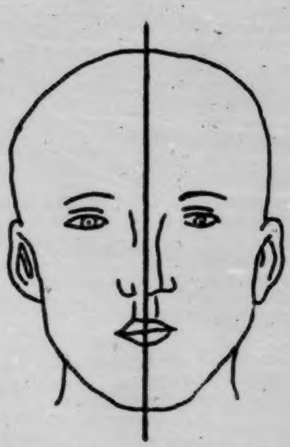
37. The skull is divided into right and left halves by the

_____________________ plane.

---

37. Midsagittal plane

38.



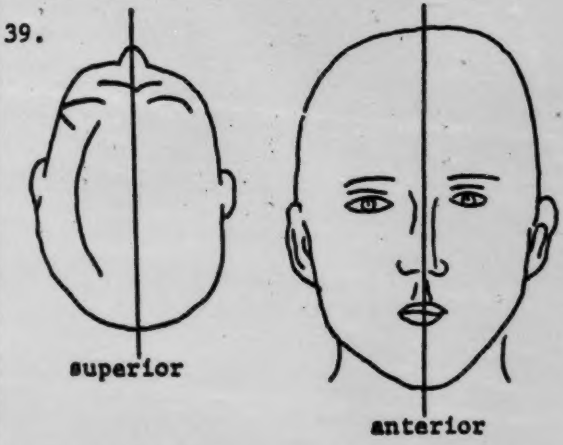
This drawing represents the

_____________________ plane.

---

38. Midsagittal plane

39.



The lines of this illustration represent the _______________ plane.

39. **Midsagittal plane**

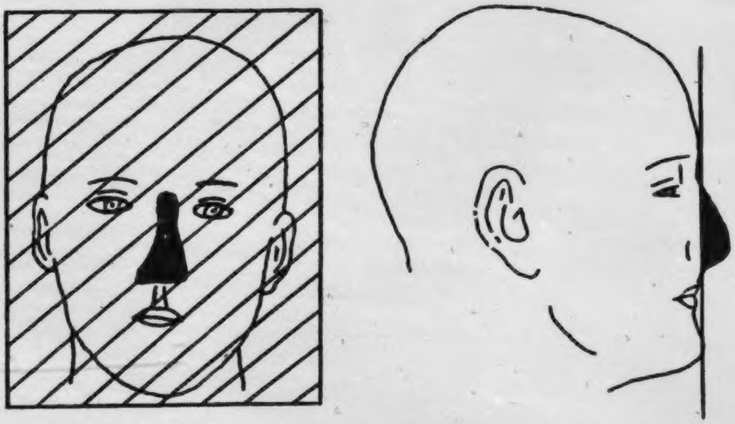
40. The facial plane is perpendicular to the midsagittal plane and is the second plane of the skull that we will discuss. This plane passes through the glabella and the mental protuberance. The plane that is perpendicular to the midsagittal plane, passing through the glabella and the mental protuberance is the

________________________ plane.

---

40. **Facial plane**

41.



Imagine placing your face up against a window with your nose being able to protrude through the glass. If the midsagittal plane is perpendicular to the glass, and the glabella and mental protuberance are touching the surface of the glass, the glass would represent the

F_______________________ plane.

41. Facial plane	42. The facial plane is perpendicular to the ______________ plane and passes through the ________________ and the _____________ protuberance.
42. Midsagittal plane Glabella Mental protuberance	43. The plane passing through the glabella and the mental protuberance that is perpendicular to the midsagittal plane is called the ____________________ plane.
43. Facial plane	44. The two planes that we have studied are the _____________________ plane and the __________________ plane.
44. Midsagittal plane Facial plane	45. The plane passing through the mental protuberance, glabella, and the external occipital protuberance is known as the ________________ plane.
45. Midsagittal plane	46. The plane that is perpendicular to the midsagittal plane passing through the glabella and mental protuberance is the ______________________ plane.
46. Facial plane	

SECTION IV - ANNEXES

ANNEX B

RADIOGRAPHIC PHYSICS

Peacetime: 83 hours
Mobilization: 83 hours

OBJECTIVE: Apply the knowledge of radiographic physics to obtain a quality diagnostic radiograph. Apply correct radiation protection procedures when using ionizing radiation devices.

Subject and LP No	Lesson Objective	References
Basic Math Review	Calculate from memorized formulas to find any of the following unknown factors: mA, s, mAs; centimeters, inches; heat units; DCF, ALD, DC, FFD.	TM 8-280, pp 1-1 thru 1-11, para 1-1 thru 1-11; p 5-6, para 5-12; pp 6-25 thru 6-26, para 6-19c; p 6-27, para 6-23.
History of X-Rays LP 38-520-002	State: Who discovered X-rays, how, when (year); the contributions of Dr. Grubbe to radiology; the two medical areas which utilize X-rays.	Selman, pp 148-149.
Theory and Properties of X-Rays	Convert centimeters to inches and vice versa. Identify the following on a diagram of a sine wave: One cycle; wavelength. Define frequency, cycle, wavelength. Match all others when given a comparative value of any one of the following: Frequency, wavelength, energy, penetration, kind of ray. List at least seven properties of X-rays.	Selman, pp 149-158.
Atomic Structure	Identify definitions or descriptions of the following terms: Atom, element, proton, electron, neutron, atomic number, atomic weight, isotope, ion, energy level, primary and secondary radiation production. Describe the two	TM 8-280, pp 2-1 thru 2-9, para 2-1 thru 2-10, pp 2-12 thru 2-16, para 2-12;

Subject and LP No	Lesson Objective	References
	methods of primary X-ray production and relative amounts of each in the X-ray beam; the process of ionization; the Bohr theory of atomic structures.	Selman, pp 155-157, 174-179.
Introduction to Electricity	Identify or state: the four factors which affect the electrical resistance of a conductor; the type of current (AC, uniform DC, pulsating DC) represented when a given diagram of that current or a description of how it flows is given. Define the terms: Voltage, Current, Resistance. Match the term Voltage, Current, and Resistance with their respective units. Convert: Volts to kilovolts; kilovolts to volts; amperes to milliamperes; milliamperes to amperes.	TM 8-280, pp 4-1 thru 4-2, para 4-1 thru 4-5; Selman, pp 54-69.
Radiation Protection	Identify responsibilities of technicians when dealing with radiation. Identify radiation protective measures. Identify the effects of acute and chronic radiation exposure. Identify the definition of the terms rad, rem, and roentgen. State in order of most sensitive to least sensitive three types of cells that are sensitive to radiation.	TM 8-280, Chapter 3.
Radiation Protection: Specific Biological Effects	Demonstrate the proper wearing of the film badge. State the concept of cumulative radiation. State the difference between threshold and non-threshold doses. list three factors that influence the amount of the effect produced by radiation. List five effects of radiation on any type of cell. List four somatic effects of	TM 8-280, Chapter 3.

Subject and LP No	Lesson Objective	References
	radiation. List the two components of radiation injury.	
Radiation Protection: Gonad Shielding	State the goal for gonad shielding. State the four rules of thumb for using gonad shields. List five X-ray procedures for which the use of gonad shielding would be appropriate. List the three types of gonad shields. Briefly discuss the advantages and disadvantages of these types of male gonad shields.	TM 8-280. Chapter 3, para 29.
X-Ray Tubes and Charts	State the three requirements for X-ray production; the relationships between the names of the tube parts, materials of construction and/or functions; the purpose of the Tube Rating Chart. From the Tube Rating and/or Tube Cooling Charts determine whether a single exposure is safe; calculate the heat produced in a single exposure; calculate how many exposures may safely be made per minute (all formulas to be memorized).	TM 8-280 pp 5-1 thru 5-9, para 5-1 thru 5-18; Selman, pp 198-213; Film - "In The Service of Science" (Machlett).
Inverse Square Law	State how X-rays reaching the film are affected by a change in FFD. Compute the new mAs required when changing from a given exposure technique to a new FFD.	TM 8-280 pp 6-7, 6-8, para 6-7 thru 6-9; Selman,
Primary Factors of Exposure	Define primary factor. State how a change in any primary factor will affect: electrons crossing the tube; X-rays produced (quality vs. quantity). State the function of any item on the control panel of the typical X-ray machine.	TM 8-280, pp 6-7 thru 6-16 para 6-7 thru 6-13; pp 6-26 thru 6-30, para 6-20.

Subject and LP No	Lesson Objective	References
		thru 6-26; Selman, pp 239-243; P1-38-520-007-1, Film - "So This is Radiography" (Kodak).
Accessory Devices	State: The purpose of filtration, types of filtration and minimum filtration required; the purposes and/or functions of collimating devices; the definitions of grid ratio, grid focus, grid radius; the relationship between grid efficiency and grid ratio; the proper grid usage to avoid grid lines and grid cut-off; the relative efficiency of collimation as compared to grids.	TM 8-280, p 3-15, para 3-29c; p 6-21 thru 6-26, para 6-18 thru 6-19; Selman, pp 329-357.
Secondary Factors and Film Discussion	List the four secondary factors. List the two auxiliary factors (OFD & FS) which affect secondary factors. State which primary factor(s) affect(s) each secondary factor and fog and the relationship (direct or inverse) between them. State how each secondary factor and fog is affected by any given primary factor.	TM 8-280, pp 6-7 thru 6-38, para 6-7 thru 6-30; Selman, pp 298-327; P1-38-520-007-1.
Compensation Factors	Given a section of a typical Optimum kVp Technique Chart (taken from the sample chart on pp 131-134 of the Physics GR) for reference and utilizing Compensation Factor formulas from memory, compute the new exposure, specifying the kVp, mA, s, mAs and FFD which will be used when making changes in	TM 8-280, p 6-46, para 6-37c(6)(a), pp 6-21 thru 6-26, para 6-18 thru 6-19.

Subject and LP No	Lesson Objective	References
	any one or combination of up to three of the following situations for any given body part shown on the chart: (1) Patient thickness is above or below normal range. (2) Scale of Contrast is to be increased or decreased by either a drastic or moderate amount. (3) Contrast is to be increased or decreased by either a drastic or moderate amount. (4) The patient has a wet or dry cast on the part to be radiographed. (5) A change in grids is to be made to include any of the following: a. Change from any grid ratio (5:1, 6:1, 8:1, 12:1, 16:1) to a non-grid technique. b. Change from a non-grid to any grid ratio. c. Change from one grid ratio to another grid ratio. (6) FFD is increased requiring a change in mAs. (7) Age and physical condition (children, aged, bedridden) are not normal.	
Radiographic Exposure Technique	State the differences which exist between: The theories of Variable kVp and Optimum kVp techniques; typical Variable kVp and Optimum kVp chart formats. List at least three advantages of Optimum kVp over Variable kVp techniques. Determine the "proper" exposure to be used for a given body part when given a specific technique chart or "Supertech" slide rule.	TM 8-280, pp 6-42 thru 6-49, para 6-36 thru 6-37; Selman, p 317; Kratzer; Cahoon, pp 137-228.
Construction and Handling of X-Ray Film	Name the: Material of which X-ray film base is made; materials of which X-ray film emulsion is made;	TM 8-280, pp 7-10 thru 7-20, para 7-16

245

Subject and LP No	Lesson Objective	References
	light-sensitive material in X-ray film emulsion. Describe the: Function of gelatin in the emulsion of the film; function of silver bromide in the emulsion of the film; process of converting the latent image to a visible image; correct method of holding a film with one hand; effects of age and heat on a film. Define Latent Image.	thru 7-25; Selman, pp 256-257; Film - "Inside Story" (Kodak).
Film Holders ✓ and Hangers	Identify the parts of a cardboard holder or cassette when given a cross-sectional diagram of the holder. Name the fluorescing crystals on intensifying screens. Describe: The construction of an intensifying screen; proper film handling techniques in loading and unloading cardboard holders and cassettes. Match intensifying screen crystal size with each of the following factors: Speed of screens; detail produced on film; contrast produced on the film.	TM 8-280, pp 6-38 thru 6-42, para 6-31 thru 6-35, pp 7-9 thru 7-10, para 7-11; Selman, pp 256-268.
Darkroom Construction	State the advantages and/or disadvantages of each of the three types of darkroom entrances; two types of darkroom lighting and conditions of use for each. List the items of equipment located in the manual processing darkroom on the: dryside; wetside.	TM 8-280, pp 7-1 thru 7-9, para 7-1 thru 7-9; Selman, pp 270-274.
Darkroom Processing	State (when using the hand processing system) the functions of developer rinse, fixer, wash-in film processing; factors which affect film development time; duration of processing	TM 8-280, pp 7-20 thru 7-44, para 7-26 thru 7-56; Selman, pp 278-296.

257

Subject and LP No	Lesson Objective	References
	in each chemical solution; effect on a film of any of the following incorrect procedures: 1, develop but not fix; 2. fix but not develop; 3. insufficiently wash. Describe (when using the hand processing system) the: Order of use of chemical solutions; methods of film handling.	
Artifacts ✓	Given a specific artifact (developer splash, fixer splash, static electricity, dirty or damaged screens, light fog, crinkle marks, foreign object) state: At what point in handling it was produced; how it would appear on the film in terms of characteristic shape or appearance, dark vs. light; which technologist was responsible for producing it; how it was produced; how it could have been avoided.	TM 8-280, pp 7-45 thru 7-47; Table 7-4; Selman, pp 285-290.
Electricity: Ohm's Law and AC and DC	List the three basic electrical factors. Define AC cycle, frequency, impulse. Diagram simple series and parallel circuits. State: Ohm's Law; the type of current represented in a given diagram; how electrical paths, voltages, currents, and total resistances compare in series and parallel circuits. Convert (when given the frequency): AC impulses to seconds of exposure; seconds of exposure to AC impulses.	TM 8-280, pp 4-1 thru 4-3, para 4-3 thru 4-7; Selman, pp 70-80.
Magnetism and Electromagnetism	Name one electromagnetic device which operates using: relative motion, mutual induction, self-induction. Define electromagnetism, electromagnetic induction. State the fundamental law of	TM 8-280 pp 4-5 - 4-9, para 4-9 thru 4-20; Selman, pp 84-102 and 132-133.

Subject and LP No	Lesson Objective	References
	magnetism, electromagnetic principle involved and its function for each of the following devices: 1. Generator; 2. Choke coil; 3. relay (contactor); 4. Transformer; 5. Autotransformer.	
Transformers and Autotransformers	List the two types of transformers; the components which comprise the transformer and autotransformer. State the principles of electromagnetic induction used in the transformer and autotransformer; the functions of the step-up transformer and the autotransformer. Define transformer. Describe the operation of the transformer; the difference in construction of the step-up and step-down transformers. Calculate the primary (or secondary) voltage and current when given the transformer ratio and the secondary (or primary) voltage and current.	TM 8-280, pp 4-13 thru 4-16, para 4-27 thru 4-30; Selman, pp 120-129.
Meters and Timers	List the four types of timers in order of increasing accuracy and desirability. State the purpose of the ammeter, volmeter; how the ammeter and voltmeter are connected into a circuit; the uses of the ammeter, milliammeter and the milliampere-second meter; the reason why the electronic timer is the preferred type of timer.	TM 8-280, pp 4-12 thru 4-13, para 4-26; Selman, pp 116-119.
Rectification	Define rectification; valve tube. State the three requirements for valve tube operation; the type of rectified current which results when using each of the following: self-rectified	TM 8-280, pp 4-16 thru 4-20, para 4-31 thru 4-36; Selman, pp 136-146.

Subject and LP No				Lesson Objective	References
				tubes, single-valve tube rectification, two-valve tube rectification, full wave rectification; the uses of the Spin Top Test. Convert (when given frequency of AC and type of rectification) impulses to seconds of exposure and seconds of exposure to impulses. Perform mathematical computations (from memorized relationships) using the Spin Top Timer-Rectification test in any of the following situations: Given an exposure time, determine how many dots should be produced when using either full-wave or half-wave rectification in either the United States or overseas (four possible situations). Given the number of dots produced with a given mA value and a specified mode of rectification in a given geographical location, determine the exposure time used, what mAs was produced, whether the timer was faulty and, if so, whether it runs too fast or too slowly, whether the rectification system is malfunctioning, and whether a combination of 3 and 4 exists.	
X-Ray Machine Circuits				Given a schematic diagram of a basic X-ray machine circuit (refer to page 205 of Physics GR) for reference, locate any specific component in the diagram when given its name or function. Identify any indicated component in the diagram; specify the electrical function of any indicated component in the diagram; identify the sub-circuit of which any component is a member.	TM 8-280, pp 4-21 thru 4-26, para 4-37 thru 4-42; Selman, pp 228-255.

249

Subject and LP No				Lesson Objective	References
Electrical Protection				State the reason for grounding X-ray equipment; at least two acceptable locations for grounding a portable X-ray machine; the conditions under which electrical arcing is a hazard when using X-ray equipment.	TM 8-280, pp 4-26 thru 4-30, para 4-43 thru 4-48; Selman, p 479.

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

Mr. John Mayes
*LP 38-520-005
016

Basic Math Review (8 hours)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES:

TM 8-280, pp 1-1 to 1-11, 5-6
Selman, Joseph. The Fundamentals of X-ray and Radium Physics. 4th ed. Springfield, Ill: Charles C. Thomas, Publisher, 1970, pp 3-23

STUDY ASSIGNMENT: TM 8-280, pp 1-1 to 1-11, 5-6

STUDENT UNIFORM AND EQUIPMENT: TM 8-280, GR 38-520-001-1

TOOLS, EQUIPMENT, AND MATERIALS: N/A

PERSONNEL: One instructor (91P2H or 91P4H)

INSTRUCTIONAL AIDS: Chalk, chalkboard, eraser

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Practical Exercise (1st-4th hrs) Lecture and Practical Exercise (5th-8th hrs)

FIRST AND SECOND HOURS

I. INTRODUCTION:

A. Opening Statement: A working knowledge of the basic mathematical operations is essential for each individual in the field of Radiologic Technology. As this course progresses we will introduce all of the necessary formulas that you will need to correctly set up an exposure technique. The purpose of this four hour block of instruction is to refamiliarize you with such operations as addition, subtraction, multiplication and division of whole numbers and fractions based on problem areas which became evident in your premath test. Simplified algebraic expressions will also be covered.

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*This lesson plan supersedes LP 38-520-005, 083

251

B. Objectives

1. After review, Properly compute problems involving addition, subtraction, multiplication and division of fractions and whole numbers.

C. Class Procedure and Lesson Tie-in

None

II. EXPLANATION (80 min)

A. Improper Fractions

1. Terms and Definition

a. Numerator: The part of the fraction above the line. (number of parts)

b. Denominator: The part of the fraction below the line. (size of parts)

NOTE: The numerator is larger than the denominator in an Improper fraction.

2. Examples

NOTE: See Annex A (sec. A)

3. Rule

a. Convert improper fraction to mixed number

B. Mixed Number

1. Definition

a. Whole number plus fraction

2. Conversion

a. Divide denominator of improper fraction into numerator

b. Examples

NOTE: See Annex A (sec. A)

C. Changing common fraction to decimal fraction

1. Method

   a. Divide numerator by denominator

2. Examples

NOTE: See Annex A (sec. B)

D. Addition of Fractions

1. Method

   a. Select lowest common denominator

   b. Add numerators

   c. Reduce fraction

2. Examples

NOTE: See Annex A (sec. C)

E. Subtraction of Fractions

1. Method

   a. Select lowest common denominator

   b. Subtract numerators

   c. Reduce fraction

2. Examples

NOTE: See Annex A (sec. D)

QUESTION: How do we convert common fractions to decimal fractions?

ANSWER: Divide the numerator by the denominator.

253

F. Multiplication of Fractions

1. Method

a. Multiply numerator by numerator and denominator by denominator

b. Reduce fraction if possible

NOTE: See Annex A (sec. E)

3. Cancellation

NOTE: Cancellation may be performed only across multiplication sign. See examples in IM.

QUESTION: How do we multiply fractions?

ANSWER: Multiply numerator by numerator over denominator by denominator.

G. Division of Fractions

1. Method

a. Invert denominator and multiply

b. Cancel to reduce

2. Examples

NOTE: See Annex A (sec. F)

H. Simple Algebraic Expressions

1. Method

a. Substitute numerical values for appropriate letters in expression

b. Perform indicated operation

2. Examples

NOTE: See Annex A (sec. G)

I. Squaring

1. Method

a. Multiply number by itself

b. Operation indicated by superscript two

2. Examples

NOTE: See Annex A (sec. H)

J. Questions from Students

III. SUMMARY (5 min)

A. Review of Main Points

1. Conversion of improper fractions to mixed numbers

2. Addition of fractions

3. Subtraction of fractions

4. Multiplication of fractions

5. Division of fractions

6. Algebraic expressions

7. Squaring .

B. Closing Statement: A thorough understanding of and an ability to use fractions and whole numbers in various mathematical operations will be an invaluable aid to you as an X-ray Technologist in obtaining diagnostic radiographs.

THIRD AND FOURTH HOURS

I. INTRODUCTION (5 min)

A. Opening Statement: Now that we have completed our review of basic mathematics, we are ready to look at some particular types of problems related to x-ray and introduce the formulas which are used in solving them. Without the working knowledge of these few formulas, you as technicians cannot be assured that your technique factors are correct when a change from a given technique is required.

B. Objectives

1. Describe and demonstrate the proper usage of each of the following formulas:

a. $cm = \frac{in}{.4}$ or $in = .4 \times cm$

b. $mAs = mA \times s$

c. $HU = kVp \times mAs$

d. $ALD \times DCF = DC \times FFD$

C. Class Procedure and Lesson Tie-in

None

II. EXPLANATION (180 min)

NOTE: See Annex B and follow printed outline. (Students using GR 38-520-001-1, have major underlined headings filled in and must fill in their notes as per Annex B.)

QUESTIONS FROM STUDENTS:

III. SUMMARY (5 min)

A. Review of Main Points

1. Converting centimeters to inches and inches to centimeters

2. mAs

3. Heat units

4. Cones and extension cylinder adjustments

B. Closing Statement: You should now be able to work several types of problems which are necessary in the production of diagnostic radiographs. Too much emphasis cannot be placed on your ability to solve these problems. Learn them well and review them often.

ANNEX A
INSTRUCTIONAL AIDS

NOTE: All problems indicated herein may be utilized as examples for the students in addition to any others the instructor may deem necessary.

A. Improper Fractions and Mixed Numbers

1. 5/3
2. 8/5
3. 3/2 = 1½
4. 5/3 = 1 2/3
5. 15/3 = 5
6. 50/4 = 12½
7. 25/6 = 4 1/6
8. 170/3 = 56 2/3

B. Change common fractions to decimal fraction

1. 1/2 = 0.50
2. 5/3 = 1.66
3. 15/3 = 5
4. 2/3 = 0.66
5. 3/4 = 0.75
6. 3/7 = 0.43
7. 1 3/4 = 1.75
8. 4 5/8 = 4.62

C. Addition of Fractions

1. ½ = ½ = 1.0
2. 1/2 + 1/4 = 2/4 + 1/4 = 3/4
3. 3/5 + 5/15 = 9/15 + 5/15 = 14/15

D. Subtraction of Fractions

1. 1/2 - 1/4 = 2/4 - 1/4 = 1/4
2. 2/3 - 1/4 = 9/12 - 3/12 = 6/12 = 1/2
3. 1/3 - 1/5 = 5/15 - 3/15 = 2/15

E. Multiplication of Fractions

1. 1/2 x 2/3 = 2/6 = 1/3
2. 3/4 times 2/3 = 6/12 = 1/2
3. 3/4 of 60 = 180/4 = 45
4. (8/7) (84) = 712/7 = 101 5/7
5. 1 1/4 x 12 1/2 = 5/4 x 25/2 = 125/8 = 15 5/8
6. 150 x 3/10 = 450/10 = 45
7. Cancellation: Select the situations in which cancelling is permitted. Cancel as much as possible without solving the problems.

   a. 4/5 x 25/33 ...... 4/1 x 5/33
   b. 18/25 = 4/3 ...... cannot cancel
   c. 3/8 ÷ 16/21 ...... cannot cancel
   d. 2/3 x 5/18 ...... 1/3 x 5/9

F. Division of Fractions

1. 1/2 ÷ 2/3 = 1/2 x 3/2 = 3/4
2. 3/5 ÷ 3/8 = 3/5 x 8/3 = 8/5 = 1 3/5
3. 50 ÷ 1/4 = 50 x 4/1 = 200
4. 37 1/2 ÷ 3/4 = 75/2 ÷ 3/4 = 75/2 x 4/3 = 50
5. 3 3/4 ÷ 3/20 = 15/4 ÷ 3/20 = 15/4 x 20/3 = 25

G. Algebraic Expressions

1. A = B x C ...... A=? , B = 100, C = 1/4
   = 100 x 1/4
   = 25
2. A = B x C ...... A=? , B = 25, C = 1/2
   = 25 x 1/2
   = 25/2
   = 12 1/2
3. mAs = mA x sec .... mAs = ?, mA = 20, sec = 3/8
   = 20 x 3/8
   = 5 x 3/2
   = 15/2
   = 7 1/2

4. A/B = C .... A = 25, B = 1/4, C = ?
   25/ 1/4 =
   25 ÷ 1/4 =
   25 x 4/1 =
   100 = C

5. mAs/ sec = mA .... mAs = 7 1/2, sec = 3/8, mA = ?
   7 1/2 / 3/8 =
   15/2 x 8/3 =
   5 x 4 =
   20 = C

6. A/20 = 16 / 40 ... A = ?
   A/16 = 2/5
   A = 32/5
   A = 6 2/5

7. 8/15 = C/25 ... C = ?
   8/15 x 25 = C
   8/3 x 5 = C
   40/3 = C
   13 1/3 = C

H. Squaring

1. $3^2 = 3 \times 3 = 9$

2. $5^2 = 5 \times 5 = 25$

3. $Z = 50 \times 30^2 / 60^2$ ... Z = ?

   $= 50 \times 3^2 / 6^2$

   $= 50 \times 9/36$

   $= 25 \times 9/18$

   $= 225/18$

   $= 12.25$

ANNEX B
INSTRUCTIONAL AIDS

A. Terminology

1. Subscript

a. Definition: A number written immediately below and to the right of another character

b. Examples

1) mAs_1

2) FFD_2

2. Squaring

a. Definition: To multiply a number by itself

b. Examples

1) $3^2 = 3 \times 3 = 9$

2) $FFD^2 = FFD_1 \times FFD_1$

3. Ratio

a. Definition: A relationship in quantity or amount between two or more things

b. Examples

NOTE: Draw and explain this chart on board.

Examination	Barium (Ba)	Water
Ba swallow	6	1
Ba meal	1	1
Ba enema	1	8

4. **Proportion**

   a. **Definition**: A relationship of equality between two or more ratios

   b. **Examples**

      1) $4/8 = 3/5$

      2) $5/10 = 1/2$

5. **Equations**

   a. **Definition**: An expression of equivalence of mathematical expressions

   b. **Examples**

      1) $\text{cm} = \text{in.} \div .4$

      2) $\text{mAs} = \text{mA} \times \text{s}$

      3) $\text{HU} = \text{kVp} \times \text{mA} \times \text{s}$ or/

         $\text{HU} = \text{kVp} \times \text{mAs}$

      4) $\text{ALD} \times \text{DCF} = \text{FFD} \times \text{DC}$

C. Centimeters Formula

1. **Theory** As use of the metric system becomes more prevalent in this country it is important that you understand conversions between the English and metric system. A basic unit of measure that you will commonly use is the centimeter.

2. **Formulas**

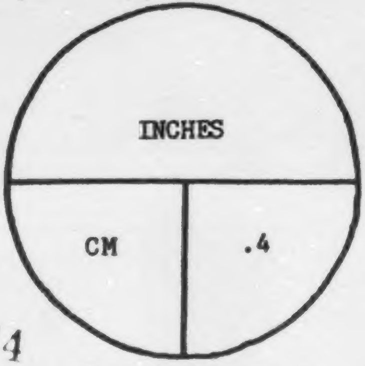
a. Inches = Centimeters X ____4____

NOTE: See Section 4 B-4 for appropriate problems

b. Centimeters = $\dfrac{\text{Inches}}{.4}$

NOTE: See Section 4 B-4 for appropriate probelms.

c. Memory Wheel



4. **Problems**

a. 15 cm = 5.91 in

* b. 21 cm = 8.27 in

c. 12 cm = 4.72 in

d. 4 in = 10.16 cm

* e. 2½ in = 6.35 cm

f. 9 in = 22.86 cm

g. 9 cm = 3.54 in

h. 10 in = 25.4 cm

i. 7 cm = 2.76 in

j. 8 in = 20.32 cm

264

D. mAs Formula

1. Theory When the appropriate constant is added the mAs formula tells how many electrons travel from cathode to anode.

NOTE: mAs = mA x s
= electrons$_{/sec}$ x sec x 6 x 10^{15} electrons
= electrons x 6 x 10^{15} electrons

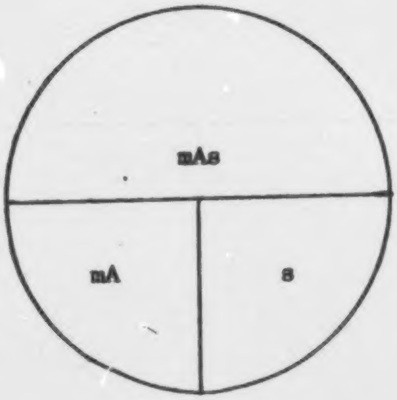
2. Formula

a. mAs = mA x s

b. mA = mAs$_{/s}$

c. s = mAs$_{/mA}$

3. Memory Wheel



4. Examples

NOTE: See Section 5 page B-6, B-7 for example problems

5. Problems

	mA	s	mAs
a.	100	2	200
* b.	100	½	50
c.	20	3/4	15
d.	20	1.5	30
e.	50	1/5	10
* f.	4	.5	2
g.	300	1/20	15
h.	50	2/5	20
i.	20	3/8	7½
* j.	100	3/10	30
k.	25	5/8	15 5/8

	mA	s	mAs
l.	25	1/20	1¼
m.	100	3/5	60
* n.	25	1/10	2½
o.	10	3/8	3.75
p.	20	3/8	7½
q.	50	1/10	5
* r.	50	4/5	40
s.	10	5/8	6¼
t.	20	3/4	15

E. Heat Units

1. Theory: Tells how much heat is built up on anode.

QUESTION: Which factors affect the amount of heat built on the anode during an exposure?

ANSWER: kVp, mA, s all affect the amount of tube heating.

NOTE: Heat units are electrically equivalent to watt-seconds.

2. **Formula**

   a. HU = kVp x mA x s

   b. HU = kVp x mAs

NOTE: Both formulas are equivalent.

3. **Examples**

NOTE: See Section 4, page B-8 and B-9 for example problems.

4. **Problems**

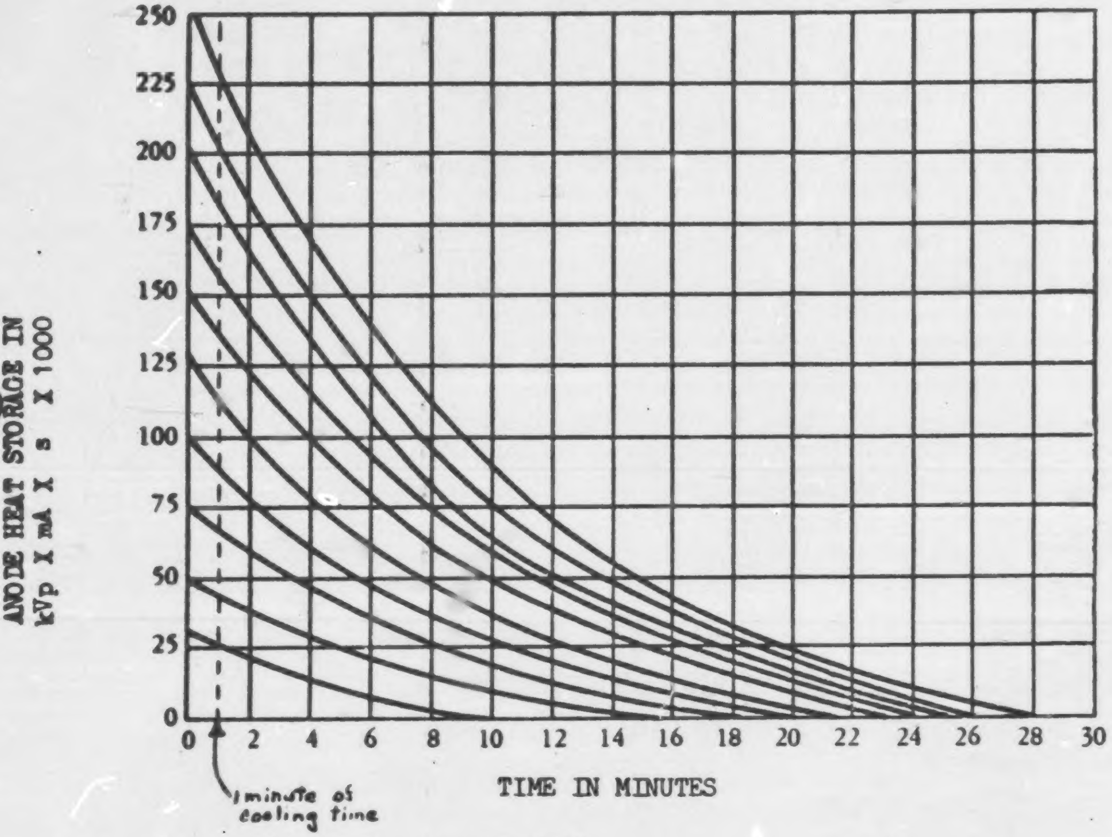
	HU	kVp	mA	s	mAs
a.	150	60	25	1/10	2.5
b.	2550	85	50	3/5	30
c.	1875	75	50	1/2	25
d.	525	70	5	1.5	7½
e.	1687.5	75	25	9/10	22½
* f.	675	90	10	3/4	7½
g.	3000	50	100	3/5	60
h.	1050	70	20	3/4	15
i.	265.6	85	5	5/8	3 1/8
* j.	600	80	20	3/8	7½

		HU	kVp	mA	s	mAs
	k.	4250	85	10	5	50
	l.	150	60	25	1/10	2½
	m.	812.5	65	20	5/8	12½
*	n.	1000	50	100	1/5	20
	o.	2250	90	50	½	25
	p.	210	70	4	3/4	3
	q.	75	60	2½	1/2	1¼
*	r.	875	70	20	5/8 (.625)	12½
	s.	812.5	65	25	½	12½
	t.	1200	80	50	3/10	15

5. **Tube Cooling Chart:** Used when making large numbers of exposures. Tells how long is required for the tube to dissipate heat.

QUESTION: How is the x-ray tube cooled?
ANSWER: The tube is cooled by circulating oil and air.

NOTE: Explanation of usage of chart in IM.



6. Exposures per minute--EPM
   a. Maximum cooling rate (MCR) - based on tube cooling chart
   b. Formula
      1. EPM = MCR/HU
      2. Tells how many safe exposures may be made in one minute with a particular exposure technique.

NOTE: See Section 7 for sample problems.

7. Problems:

NOTE: Using a maximum cooling rate (MCR) of 25,000 HU/min calculate for each problem the heat units produced and the maximum permissible number of exposures per minute which could be continuously produced without burning out the tube.

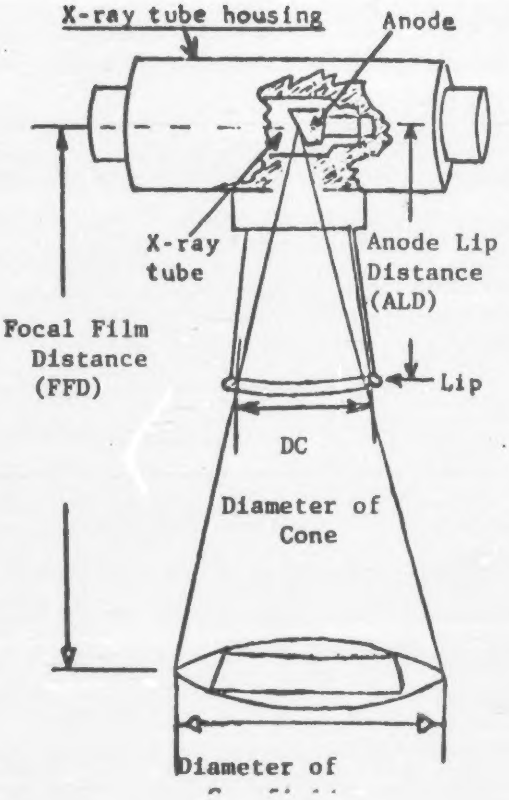
	kVp	mA	s	HU	EPM
a.	80	100	1/10	800	31
b.	75	300	2/5	9000	2
c.	50	300	2/5	6000	4
d.	95	100	1½	14250	1
e.	65	250	½	8125	3

F. DCF--ALD Formula

1. Theory This formula becomes important when the technician must choose the appropriate coning device to give a specified cone field on the film. It is becoming absolete as usage of collimators becomes more prevalent.

NOTE: As of August 1, 1974, all new x-ray machines manufactured must be equipped with a collimator.

NOTE: Label diagram as given.


X-ray tube housing
Anode
X-ray tube
Anode Lip Distance (ALD)
Focal Film Distance (FFD)
Lip
DC
Diameter of Cone
Diameter of

271

2. Equation

a. $\frac{ALD}{FFD} = \frac{DC}{DCF}$

b. ALD x DCF = DC x FFD

NOTE: Both equations are equivalent.

3. Application

NOTE: See Section 4 for example problems.

4. Problems

	FFD	ALD	DCF	DC
a.	40	20	8	4
* b.	30	10	12	4
c.	48	16	12	4
d.	30	7½	12	3
e.	36	8	13½	3
* f.	25	16 2/3	6	4
g.	48	2½	9	.46
h.	30	3	14	1.4
i.	40	5	20	2.5

LP 38-520-005
016

		FFD	ALD	DCF	DC
*	j.	40	8½	18.8	4
	k.	40	16	10	4
	l.	60	2½	6	.25
	m.	72	2½	18	5/8
*	n.	40	8	15	3
	o.	36	16	9	4
	p.	48	12.8	15	4
	q.	30	8½	14.1	4
*	r.	36	3	12	1
	s.	60	9	26.7	4
	t.	28	7½	11.2	3

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DIVISION OF MEDICINE AND SURGERY
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016

FRACTIONS--A REVIEW

A fraction is a part of a whole number. The fraction ½ has two parts.

The upper number is called the NUMERATOR; the lower number is called the DENOMINATOR; the horizontal line between the numerator and denominator means "numerator divided by denominator" or "1 divided by 2" in our example.

The DENOMINATOR of any fraction tells us into how many equally sized parts the whole number was divided. The NUMERATOR tells us how many of those parts we have.

There are two types of fractions: PROPER FRACTIONS (example: $\frac{3}{4}$) in which the numerator is smaller than the denominator and the value of the fraction is less than 1; and IMPROPER FRACTIONS (example: $\frac{4}{3}$) in which the value of the fraction is greater than 1.

In the x-ray course, we are not going to add or subtract fractions but multiplication and division of fractions will be common.

MULTIPLICATION OF FRACTIONS Example: $\frac{3}{4} \times \frac{1}{2} = \frac{3}{4} \times \frac{1}{2} = \frac{3}{8}$

RULE:
(1) Multiply the numerators to give the new numerator.
(2) Multiply the denominators to give the new denominator.
(3) Reduce if possible.

DIVISION OF FRACTIONS Example: $\frac{25}{2} \div \frac{1}{4} = \frac{25}{\cancel{2}_1} \times \frac{\cancel{4}^2}{1} = 50$

RULE:
(1) Invert the divisor (that is the number AFTER the ÷ sign) and multiply.
(2) Follow all multiplication rules.

CANCELLING

Cancelling will greatly simplify your work IF you follow the rules of cancelling correctly. Many people cancel at the wrong times.

EXAMPLE A: $\frac{3}{\cancel{4}_2} \times \frac{\cancel{2}}{5}$ This is LEGAL! The answer is $\frac{3}{10}$

EXAMPLE B: $\frac{\cancel{2}^1}{\cancel{3}_1} = \frac{\cancel{12}^4}{\cancel{18}_9}$ This is ILLEGAL! Note that the result says that

$$\frac{1}{1} = \frac{4}{9}$$

EXAMPLE C: $\frac{\cancel{2}^1}{\cancel{3}_1} \div \frac{\cancel{3}^1}{\cancel{4}_2}$ This is ILLEGAL! This would give an answer of 2 after inverting and multiplying. The correct answer is $\frac{8}{9}$.

The ONLY time we can cancel from the numerator to the denominator of different fractions is when the fractions are being multiplied. Note in EXAMPLE A we are multiplying so we can cancel.

In EXAMPLE B, two fractions are equal, NOT multiplied, and therefore, a wrong answer would result. In EXAMPLE C, we are dividing and we cannot cancel UNTIL we invert and multiply.

THINGS TO NOTE:

You can save yourself many incorrect answers by looking at the answer of a problem you have just worked and asking yourself, "Does this answer make sense?" Check these items to see if they do make sense.

1. Did you solve your problem by dividing the numerator by the denominator?

   Example: $\frac{2}{3}$ is the same as $3\overline{)2} = .6666....$

   Do not get in the habit of dividing the small number into the large one -- sometimes that is not correct.

2. If you multiply by a fraction which value is less than 1 (a proper fraction) your answer will be SMALLER than your first number.

   Example: $20 \times \frac{3}{4} = \frac{\cancel{20}^5}{1}\,\frac{3}{\cancel{4}_1} = 15$ 15 is SMALLER than 20.

3. If you multiply by a number greater than 1 (an improper fraction) your answer is larger than your first number.

   Example: $50 \times 1\frac{1}{2} = \frac{\cancel{50}^{25}}{1} \times \frac{3}{\cancel{2}_{1}} = 75$ 75 is LARGER than 50

4. If you divide by fractions, your results are opposite in size from what you got when multiplying.

   Example: $20 \div \frac{3}{4} = \frac{20}{1} \times \frac{4}{3} = \frac{80}{3} = 26\frac{2}{3}$

   Dividing by a proper fraction gives a larger answer.

   (Note the same figures are used in this example as in the example for multiplication by a proper fraction.)

   Example: $50 \div 1\frac{1}{2} = \frac{50}{1} \div \frac{3}{2} = \frac{50}{1} \times \frac{2}{3} = \frac{100}{3} = 33.333$

Now that we have completed our review of basic mathematics, we are ready to look at some particular types of problems related to x-ray and introduce the formulas which are used in solving them. Without the working knowledge of these few formulas, you as technicians cannot be assured that your technique factors are correct when a change from a given technique is required.

As we approach the complete conversion in this country to the metric system it becomes increasingly important for those of us in the medical field to keep abreast of the change. As X-ray Technicians perhaps the most common usage of the metric system will be in measuring patient thickness. The basic unit we will use is the centimeter (cm). One cm equals approximately 0.4 inches. Therefore, to convert inches to centimeters simply divide the number of inches by 0.4. If you want to convert centimeters to inches just multiply the number of centimeters by 0.4.

There are several formulas that X-ray Specialists commonly use in their daily work in the clinic. Perhaps the most commonly used formula either consciously or unconsciously is the mAs formula. By knowing what the mAs is for a particular exposure technique, the technician may readily determine the amount of radiation he is giving the patient. The formula is: mAs = mA x s, where mA is the milliamperage (electrons/sec) and s is the time in seconds.

By doing a quick derivation as follows, it is seen that the mAs formula actually tells us how many electrons pass from the cathode to the anode. By knowing how many electrons are involved, we can obtain some appreciation for the amount of radiation produced.

$$\begin{aligned} \text{mAs} &= \text{mA} \times \text{s} \\ &= \text{electrons}/_{\text{sec}} \times \text{sec} \\ &= \text{electrons} \end{aligned}$$

(a constant, approximately 6 x 10^{15}, must also be multiplied into this formula for the actual number of electrons involved.)

Since we are not specifically interested in the exact number of electrons involved we will omit the constant.

There are three equivalent ways tp write and use the mAs formula. They are:

$$\begin{aligned} \text{mAs} &= \text{mA} \times \text{s} \\ \text{s} &= \text{mAs}/\text{mA} \\ \text{mA} &= \text{mAs}/\text{s} \end{aligned}$$

If you have difficulty memorizing these formulas then the memory wheel should be used.

$$\frac{\text{mAs}}{\text{mA} \quad \text{s}}$$

(The horizontal line means divide. The vertical line means multiply).

EXPOSURE ARITHMETIC

The heating effect on the target of the x-ray tube is dependent on three factors: (1) kVp, mA, and s. The kVp determines how "hard" the electrons are pushed, the speed, and the energy of the electrons and, thus, the amount of energy imparted to the target during exposure. The higher the kVp the more heat is formed. The mA is the rate of electron flow toward the target. Increasing the mA sends more electrons bombarding the target in the same length of time causing more heat. Increasing the mA increases the heat. Longer s means that electrons will hit the target for a longer period of time, thus, increasing the heat since sec is the dura- of the electron flow.

The heating effect is measured in heat units. Heat units are calculated using the following formula:

$$\begin{aligned} HU &= kVp \times mA \times s \quad \text{or} \\ &= kVp \times mAs \end{aligned}$$

There is a limit as to how many heat units the tube can withstand. This limit, along with how fast the tube can dissipate its heat, is included on the tube cooling chart. The tube cooling chart relates the heat stored in the tube to the cooling time. Referring back to the sample chart, if 125-thousand heat units were initially stored in the tube, approximately 100-thousand heat units would still remain the tube after two minutes cooling time. (This assumes that: (1) the cooling system of the tube is working, and (2) no further x-rays are made during this time.) In other words, starting with 125,000 heat units, the tube will dissipate 25,000 heat units in two minutes.

The maximum cooling rate (MCR) is found by determining the amount of heat units dissipated in the first minute with the tube at its maximum heat storage (given at the top left of the chart). On our sample chart, the maximum heat storage is 250-thousand heat units. Then in one minute, the tube cools to about 225-thousand heat units. The MCR then is 25-thousand heat units per minute. This is the approximate MCR of most tubes cooled with liquid (oil)-air cooling systems.

The tube cooling chart is usually needed only when large numbers of exposures are made per minute for a fairly long period of time. The most common occasion for using the tube cooling chart is in mass chest surveys. For normal radiography the technician cannot produce exposures fast enough for the tube to become overheated. Even in mass chest surveys if the heat units produced are always less than MCR, the tube will never burn out from this cause. This can be insured by dividing the number of heat units for each exposure into the MCR. This will give the maximum number of exposures per minute of this kind that may be continuously permitted without burning out the tube.

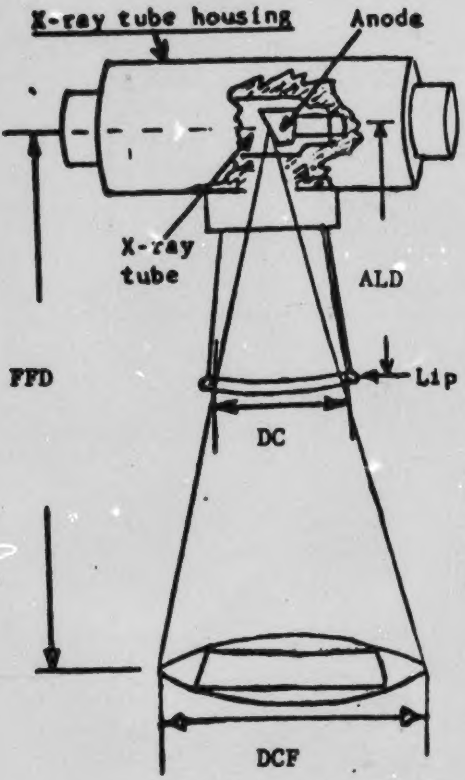
As an example, the exposure using 85 kVp and 30 mAs produces 2550 HU. By dividing 2550 into 25,000 HU/min (the MCR) we find that a maximum of 9.8 exposures could be made per minute. Note that it does not quite come out 10. If no more than 9 exposures of this value are made per minute the tube will never become overheated. Also note that you cannot take part of an exposure without changing the exposure factors. The tube rating chart should be checked to see that each single exposure is also safe.

The last formula that we have is called the DCF-ALD formula. This formula becomes important when you as the technician must choose the appropriate coning device to give a specified conefield on the film. It is becoming obsolete as usage of collimators becomes more and more prevalent. As of August 1, 1974, all nex x-ray machines manufactured must be equipped with collimator devices. Therefore, in a few years this formula should be completed outmoded.

The DCF-ALD formula is based on the law of similar triangles and the formula is:

$$\frac{ALD}{FFD} = \frac{DC}{DCF}$$

Where ALD is the anode lip distance, FFD is the Focal Film Distance, DC is the diameter of the cone and DCF is the diameter of the conefield. (See diagram next page.)


X-ray tube housing
Anode
X-ray tube
ALD
FFD
Lip
DC
DCF

By cross multiplication a derivation of this formula is obtained.

$$\frac{ALD}{FFD} \times \frac{DC}{DCF}$$

ALD X DCF = DC X FFD

Since both formulas are equivalent it does not matter which form the students wish to memorize.

Physics is sometimes referred to as the "science of measurement." It follows that the language of radiographic physics is to some extent the language of mathematics. Hence, no clear understanding of roentgenography or of the x-ray machine operation can be had without some acquaintance with the elementary mathematical principles involved. The X-ray Specialist will use simple mathematics in his work and must be accurate in his calculations, as you have already seen. The specialist should have some knowledge of fractions, decimals, exponents, elementary algebra, equations, ratios, and proportions, and the basic principles of geometry dealing with angles and rectangles.

You should now be able to work several types of problems which are necessary in the production of diagnostic radiographs. Too much emphasis cannot be placed on your ability to solve these problems. Learn them well and review them often.

MODIFICATIONS

LP#38-520-002 History of X-Rays of this publication has (have) been deleted in adapting this material for use in Vocational and Technical Education. Deleted material was not available at time of publication and its exclusion does not alter the value of remaining material.

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

Mr. John Mayes
*LP 38-520-002
016

Theory and Properties of X-rays (4 hours)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES:

Selman, Joseph. The Fundamentals of X-ray and Radium Physics. 4th ed. Springfield, Illinois. Charles C. Thomas, Publisher, 1970, pp 149-158

Medical Division, Eastmasn Kodak Company. Fundamentals of Radiography. 11th ed. Rochester, N.Y.: Eastman Kodak Company, pp 7-9.

STUDY ASSIGNMENT: After class read GR 38-520-001-1 pages 5-13.

STUDENT UNIFORM AND EQUIPMENT: GR 38-520-001-1

TOOLS, EQUIPMENT, AND MATERIALS: GR 38-520-001-1 issued at beginning of 1st week of class.

PERSONNEL: One instructor (91P2H or 91P4H - X-ray Branch)

INSTRUCTIONAL AIDS: Chart "Electromagnetic Spectrum"; chalk, chalkboard, and eraser.

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Lecture (4 hours)

I. INTRODUCTION (5 min)

A. Opening Statement: If I were to start talking to you in a foreign language, you probably would not understand a word I said. Now if you were living in a country where only that language was spoken, you would have to learn to speak it in order to survive. The same is true about X-ray. If I were to start talking to you in radiological terms, you probably would not understand. Now if you are to survive in X-ray you will have to learn our language. You will have to be able to communicate in this field. A key to learning and

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*This lesson plan supersedes LP 38-520-002, 022

understanding X-ray physics in this block of instruction dealing with theory and properties of X-ray--our language.

B. Objectives

1. Convert centimeters to inches and vice versa

2. Identify the following on a diagram of a sine wave:

    a. one cycle
    b. wavelength

3. Define: frequency, cycle, wavelength.

4. List the 5 identifying characteristics of X-rays

5. Given diagrams of two different sine waves compare them using the 5 characteristics of X-rays.

6. List at least 7 properties of x-rays.

C. Class Procedure and Lesson Tie-in

N/A

II. EXPLANATION (125 min)

NOTE: See Annex A and follow printed outline. (Students using GR 38-520-001-1, 103 have major underlined headings filled in and must fill in their notes as per Annex A.)

QUESTIONS FROM STUDENTS.

III. SUMMARY (5 min)

A. Review of Main Points

1. Speed

2. Wavelength

3. Penetration

4. Absorption

5. Ionization

6. Path

B. Closing Statement: The theory and properties of X-ray are something you will be living with throughout your entire radiographic career. X-rays are not something we can take for granted. At the same time, we should not be afraid of them but we must respect and understand them if we are to survive in this thriving field of radiography.

ANNEX A
INSTRUCTIONAL AIDS

A. **Metric System**

1. **Definition**

   a. System of weights and measures based on the unit ten.

2. **Units of Length**

NOTE: Write on board as follows

a. meter - m - 39.37 inches (40 in.)

b. (1/10) decimeter - dm - 3.937 inches (4.0 in)

c. (1/100) centimeter - cm - .3937 inches (0.4 in)

NOTE: Work practice examples converting cm to in. and in. to cm.

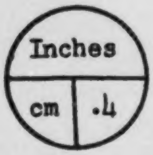
NOTE: 5 cm = (.4 x 5) = 2.0 in

12 cm = (.4 x 12) = 4.8 in

9 in = (9 ÷ .4) = 22 in

1 in = (1 ÷ .4) = 2.5 in

NOTE: Demonstrate usage of memory wheel



d. (1/1000) millimeter - mm - .03937 inches (0.04 in)

e. micron - u - 0.000001 m or 1/1,000,000 m or 10^{-6}m

f. millimicron - mu - 0.00000001m or 10^{-8}m

g. Angstrom - Å - 1/10,000,000,000m or 10^{-10}m

NOTE: Range of Diagnostic X-radiation

(0.1 - 0.5 Å)

B. Electromagnetic Concept

1. Electric Field

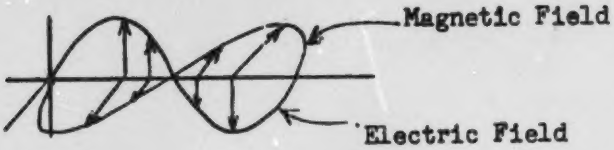
    a. Attraction and repulsion of charges

2. Magnetic Field

    b. Attraction and repulsion of poles

NOTE: Maxwell said that energy is emitted in electromagnetic waves that are a combination of electric and magnetic fields. There will be a maximum energy emitted when the waves are perpendicular and minimum energy when parallel.

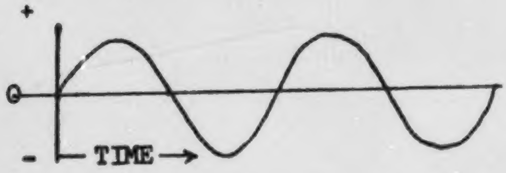
NOTE: Sketch similar to the following may be helpful



C. Electromagnetic Wave--Sine Wave

1. Sketch illustration

NOTE: Diagram of sine wave is the currently accepted means of illustrating electromagnetic waves.

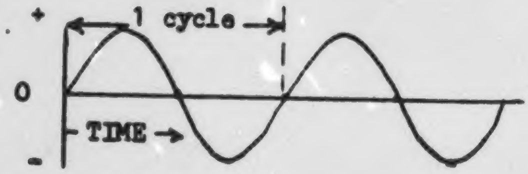


2. Terms

    a. Cycle

        1) Definition: Period of complete reversal of an alternating wave.

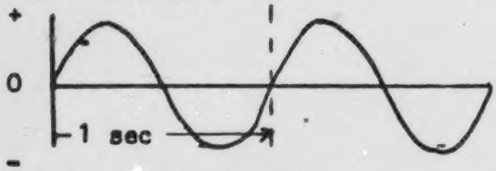
NOTE: Sketch illustration



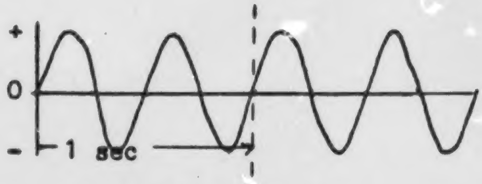
b. Frequency

1) Definition: Number of cycles per second (cps or Hertz)

NOTE: Sketch illustration



ONE CYCLE/SEC

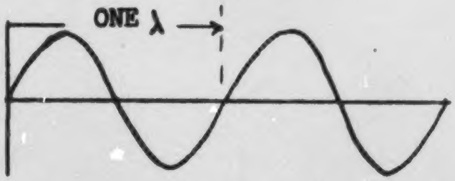


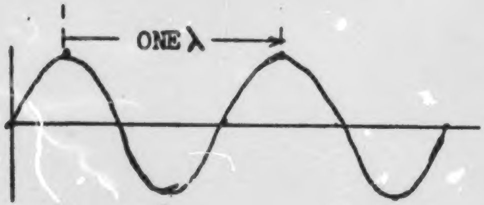
TWO CYCLES/SEC

c. Wavelength

1) Definition: linear distance of travel of one cycle (λ)

NOTE: Sketch illustration





NOTE: Recall λ of diagnostic x-radiation (.1 - .5 Å)

D. Electromagnetic Rays

QUESTION: What is the definition of wavelength?

ANSWER: Linear distance of travel of one cycle.

1. Similarities

   a. Travel in straight line

   b. Travel at speed of light ($c = 186{,}000$ mi/$_{sec}$ or 3X10^{10} cm/$_{sec}$).

   c. Photon

NOTE: A photon is defined to be one single unit of electromagnetic energy.

NOTE: Compare two ends of the electromagnetic spectru.

2. Differences

   a. Electricity

      1) $\lambda \approx$ 3100 mi.
      2) $f \approx$ 60 cps (Hz)
      3) $c =$ 186,000 mps

   b. X-radiation

      1) $\lambda \approx$ .1 - .5 Å
      2) $f \approx 10^{19}$ cps (Hz)
      3) $c =$ 3X10^{10}cm/$_{sec}$ or 186,000 mps

   c. Hard Ray

      1) High Energy
      2) Short wavelength
      3) High frequency
      4) High penetration

   d. Soft Ray

      1) Low energy
      2) Long wavelength
      3) Low frequency
      4) Low penetration

QUESTION: At what speed to all electromagnetic radiations travel?

ANSWER: The speed of light - 186,000mi/$_{hr}$.

E. Properties of X-rays (list)

1. Travel at speed of light.
2. Referred to by wavelength.
3. Produced by high speed electrons striking dense target.
4. Not reflected or refracted.
5. Travel in straight lines.
6. Absorbed by interposed dense material.

NOTE: Explain and demonstrate Pb glass absorption.

7. Heterogeneous in nature.
8. Cause fluorescence of certain crystals.

NOTE: Show and demonstrate fluorescent screen.

9. Ionize all materials through which they pass.
10. Sensitize photographic film.
11. Obey inverse square law.
12. Affect living tissue.
13. Not deflected by electric or magnetic fields.
14. Not detected by the human senses.

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

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*IM 38-520-002
016

Theory and Properties of X-rays

If I were to start talking to you in a foreign language, you probably would not understand a word I said. Now if you were living in a country where only that language was spoken, you would have to learn to speak it in order to survive. The same is true about X-ray. If I were to start talking to you in radiological terms, you probably would not understand. Now if you are to survive in X-ray, you will have to learn our language. You will have to be able to communicate in this field. A key to learning and understanding X-ray physics is this block of instruction dealing with theory and properties of X-ray --our language.

Just what are X-rays? The complete answer to this is unknown--there is no way to "look" at an X-ray. We do know what they can and cannot do. Later, we will consider the properties of X-rays, but before we can really use them we have to understand why the X-rays are as they are, how we can control them, and so forth. To get this understanding, we must study some seemingly unrelated fields. Some such fields are electricity, magnetism and the metric system.

The relationship of English units of measurements with the units of the metric system is an important one. It is a relationship which, at least in part, must be understood by any X-ray technician. For example, in measuring the thickness of the part to be radiographed, the units called centimeters are more versatile than are inches, so centimeter measurement of part thickness is almost universal. The X-ray Specialist should have some idea of the thickness of the part when given a centimeter measurement as well as the measurement of X-ray wavelength in the unit of angstroms.

The meter is the basic unit of length and is equal to a little more than a yard (39.37 inches). The meter is broken down into 100 equal sized units called centimeters which are equivalent to about 2/5 inch. One inch contains 2.54 centimeters. This relationship is very important to understand. The centimeter can be broken down into 10 equal sized segments which are called millimeters. It therefore takes 1,000 millimeters to equal 1 meter and there are 25.4 mm. per inch. The units microns (1/1000 mm.) and the millimicron (1/1000 micron) are sometimes used to measure the wavelengths of X-rays. It is more commonly found that X-ray wavelengths are expressed in angstrom units (Å). One angstrom is one hundred millionth of a centimeter or about 4 billionths of an inch.

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*This instructor's manuscript supersedes IM 38-520-002, 034

291

X-rays are similar in many ways to other types of electromagnetic rays such as light, radio waves, and so forth. An understanding of the similarities of these rays will enable you to better understand the properties of the X-rays you will use.

You are all familiar with the fact that magnets attract or repel other magnets. This attraction or repulsion is due to a magnetic field. Electricity, too, has fields of attraction and repulsion which are termed electric fields. In all electromagnetic rays we have rapidly alternating electric and magnetic fields which are acting perpendicular to each other. This is the basis of the electromagnetic concept brought about by Maxwell in 1867. He theorized that energy is emitted in the form of electromagnetic waves traveling in an oscillatory pattern.

A curve, called a sine wave, is used to represent the alternating electric or magnetic fields. Notice that this curve is repeating over and over again. If you select any point on the curve and then move along the curve to the next point which is identical with the first, you will have covered one cycle. Usually, the first point taken is at the "zero" point which gives a nice symmetrical curve to represent one cycle. The cycle is defined as a complete period of reversal of an alternating current traveling in one direction for a period of time, then in the opposite direction for the same period of time back to its point of origin. The linear distance traveled by one cycle is termed the rays' wavelength and the number of cycles that are formed per second is termed the frequency.

All electromagnetic waves are similar in that they consist of individual "packets" or "bundles" of energy called "photons" or quanta (singular: photon, quantum) which travel at the same speed: 186,000 miles per second or 30,000,000,000 centimeters per second in a vacuum. What is more, the product of the wavelength and the frequency of any electromagnetic ray will be equal to this speed of light.

There are differences between the members of the electromagnetic spectrum or family. The higher their energies the shorter are their wavelengths and conversely, the lower the energy the longer is the wavelength. Depending on the energies of the rays involved the wavelengths may vary from as long as 3,000 miles or more down to .0001 Å or shorter. (The angstrom unit (Å) = .00000001 cm.).

The electromagnetic spectrum or family consists of electromagnetic rays of widely different energies from the lowest electric waves given out by our electric wiring to the highest energies of X-rays. A table of these waves and a sample or typical wavelength and frequency are listed in the following table:

Wave	Typical Wavelength	Typical Frequency (cycles per second)
1. Electric	3,000 miles	60
2. Radio	10,000 feet	10^5
3. Television	100 feet	10^7
4. Infrared	.03 cm.	10^{12}
5. Visible light	5000 Å	6×10^{14}
6. Ultraviolet	300 Å	10^{16}
7. X-ray	0.3 Å	10^{19}
8. Gamma ray	0.03 Å	10^{20}

The proper use of X-rays depends upon your knowledge of what X-rays can and cannot do. Can X-rays bend around corners? Why do they pass through certain materials but are stopped by others? Can you feel X-rays? The answers to these questions and many others can be found in a discussion of the properties of X-rays.

Speed. Number one states that X-rays are electromagnetic radiations. These rays are made of rapidly alternating electric and magnetic fields which travel through space at 186,000 miles per second. The alternating fields may be diagramed and represented by a mathematical curve called the sine wave. (Draw a sine wave.) The distance traversed by this wave from one point to the next identical point is called the wavelength. This portion of the curve is also called one cycle. The product of the wavelength and frequency (cycles per second) equals 186,000 miles per second with all electromagnetic rays.

Wavelength. Number two says that we refer to the kind of X-rays we have by this wavelength. The longer the wavelength the lower is their energy, the less their penetrating power and the softer they are said to be. High energy, short wavelength rays are called "hard X-rays."

X-ray Production. X-rays are produced by high speed electrons striking a hard dense target. We will discuss this very completely when we discuss the X-ray tube.

Refraction and reflection. X-rays cannot be refracted or reflected to an appreciable degree. Although there is always some refraction and reflection of X-rays upon striking an object, the degree to which this occurs is so slight as to be entirely invisible on the resulting radiographs.

Travel in straight lines. X-rays, unlike flowing electricity, cannot be bent from their straight paths by electric or magnetic fields. This was tested by Roentgen to prove that the fluorescence he noted was not from electricity which passed through his vacuum tube.

Absorption. X-rays are absorbed by interposed materials. This amount of absorption depends upon the kind of material penetrated, thickness of the material, and wavelength of X-rays which are used.

Heterogeneous beam. X-rays are heterogeneous. That is, the X-ray beam is made of X-rays which have widely different wavelengths. There are several reasons for this inhomogeneity, but an understanding of this is necessary when it comes to understanding the function of certain types of accessory devices which we will take up later.

Fluorescence. X-rays will cause certain materials to fluoresce. As the energy of the X-rays is absorbed it is re-emitted as visible light of various colors depending upon the type of material.

Ionization. X-rays ionize materials through which they pass. Ionization will be explained later, but it refers to a disruption of the atoms.

Photographic effect. X-rays sensitize photographic film. This allows us to use the X-rays to produce the image on the X-ray film.

Inverse square law. X-rays obey the inverse square law. The inverse square law will be more fully explained later, but basically states that the number of X-rays striking the film is dependent upon the distance from the X-ray tube.

Effect on tissue. X-rays ionize and damage living tissues. This, of course, is the cause of X-ray hazards. More time will be spent later discussing some of these effects.

X-ray deflection. X-rays are electrically neutral and are not deflected by magnetic or electric fields.

X-rays not detected by senses. X-rays cannot be detected by the human senses, they cannot be felt, smelt, heard, tasted, or seen.

The theory and properties of X-rays are something you will be living with throughout your entire radiographic career. X-rays are not something we can take for granted. At the same time, we should not be afraid of them but we must respect and understand them if we are to survive in this thriving field of radiography.

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

Mr. John Mayes
*LP 38-520-017
016

Atomic Structure (3 hours)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES:

TM 8-280, pages 2-1 to 2-16
Selman, Joseph. The Fundamentals of X-ray and Radium Physics. 5th ed. Springfield, Illinois. Charles C. Thomas, Publisher 1972, pp 155-159, 174-179

STUDY ASSIGNMENT: After class read TM 8-280, pages 2-1 to 2-16.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 and GR 38-520-001-1

TOOLS, EQUIPMENT, AND MATERIALS: N/A

PERSONNEL: One Instructor (91P2H or 91P4H)

INSTRUCTIONAL AIDS: Chalk, chalkboard, eraser, overhead projector, 35 mm projector, S 38-520-017-1 thru 21 (see Annex B)

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Lecture (3 hours)

I. INTRODUCTION (5 min)

A. Opening Statement: In our atomic age nearly everyone knows something about atomic structure, but a proper knowledge of electricity and the formation of X-rays requires better than average concepts of the makeup of an atom. The X-ray Specialist is required to know how X-rays are produced and why they produce harmful effects to living organisms. When he understands this he will be able to produce a film of superior quality yet keep the patient dosage at a lower level.

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*This lesson plan supersedes LP 38-520-017, 010.

B. Objectives

1. Define or describe the following terms: atom; element; proton; electron; neutron; atomic number; atomic weight; isotope; ion; energy level; primary and secondary radiation production.

2. List: three forms of matter; two types of energy and identifying characteristic of each; three types of secondary radiation production.

3. Describe: the two methods of primary X-ray production and relative amounts of each in the X-ray beam; the process of ionization; the Bohr theory of atomic structure.

C. Class Procedure and Lesson Tie-in

None

II. EXPLANATION (120 Min)

NOTE: Refer to Annex A for printed outline (Students using GR 38-520-001-1 have major headings filled in and must complete their notes as per Annex A.)

QUESTIONS FROM STUDENTS

III. SUMMARY (10 Min)

A. Review of Main Points

1. Types of energy and their relationships.

2. Atomic makeup and atomic differences.

3. Types of radiation production

   a. Characteristic
   b. Braking

4. Radiation interaction with matter

   a. Scattered radiation
   b. Photoelectric effect
   c. Compton effect

B. Closing Statement: It is necessary to know the action of X-rays and how they affect film quality. Understanding the concept of production determines the method of improving the quality of useful radiation or of controlling unwanted radiation which is harmful to the patient and reduces film quality.

298

Atomic Structure

NOTE: Show S 38-520-017-1 - S 38-520-017-21
(Appropriate slides will be shown as subject is developed.)

NOTE: If desired, see Annex B for introductory annecdote.

A. Energy

1. Definition

a. Ability to do work

2. Types

a. Potential energy - P.E.

1) Stored energy
2) Due to object's position

b. Kinetic Energy - K.E.

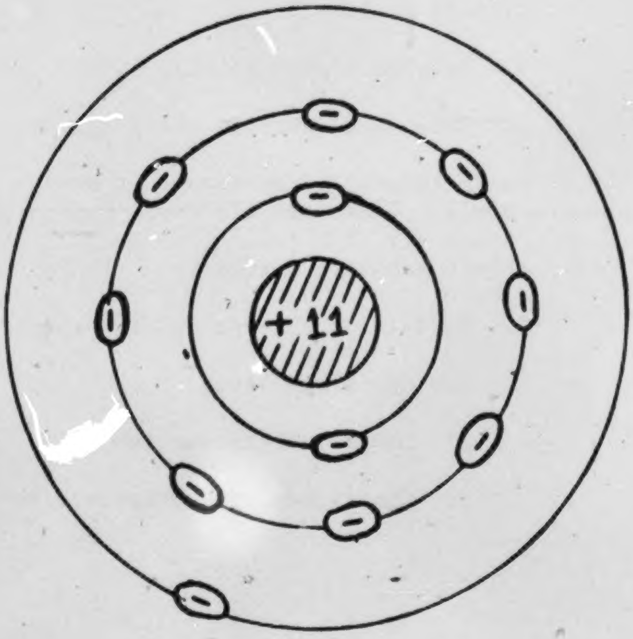
1) Energy of motion

310

B. Atomic Theory

1. BOHR Theory

NOTE: Bohr postulated that electrons exist in discrete and separate shells about the nucleus of the atom. This model may be compared to the solar system. The following diagram may be helpful as visual aid.



Atomic model as envisioned by the Bohr theory. This diagram represents an atom of sodium with 11 electrons revolving in orbit about the positive nucleus.

300

2. Atomic make-up
    a. Proton
        1) + charge
        2) In nucleus
    b. Neutron
        1) 0 charge
        2) In nucleus
    c. Electron
        1) - charge
        2) In orbital

3. Orbital Shells
    a. Labeled alphabetically (K-Q)
    b. Each shell has own characteristic energy

NOTE: Energy valve refers to the amount of energy stored in electrons at each shell. Innermost electrons have highest energy.

4. Atomic cohesive forces
    a. Definition - Force holding electrons in orbit
    b. Two opposing forces
        1) Law of electrostatics
        2) Centrifugal (centripetal) force

301

5. Atomic definitions
    a. Atomic number - number of protons
    b. Atomic weight - number of protons plus neutrons
    c. Isotope
        1) Add or subtract neutrons
        2) Element has same atomic number but different atomic weight.
6. Ionization process
    a. Definition
        1) Process by which atom gains or loses electrons
        2) Positive or negative ions
    b. Compare to electrically stable atom
    c. Basic step in characteristic x-ray production

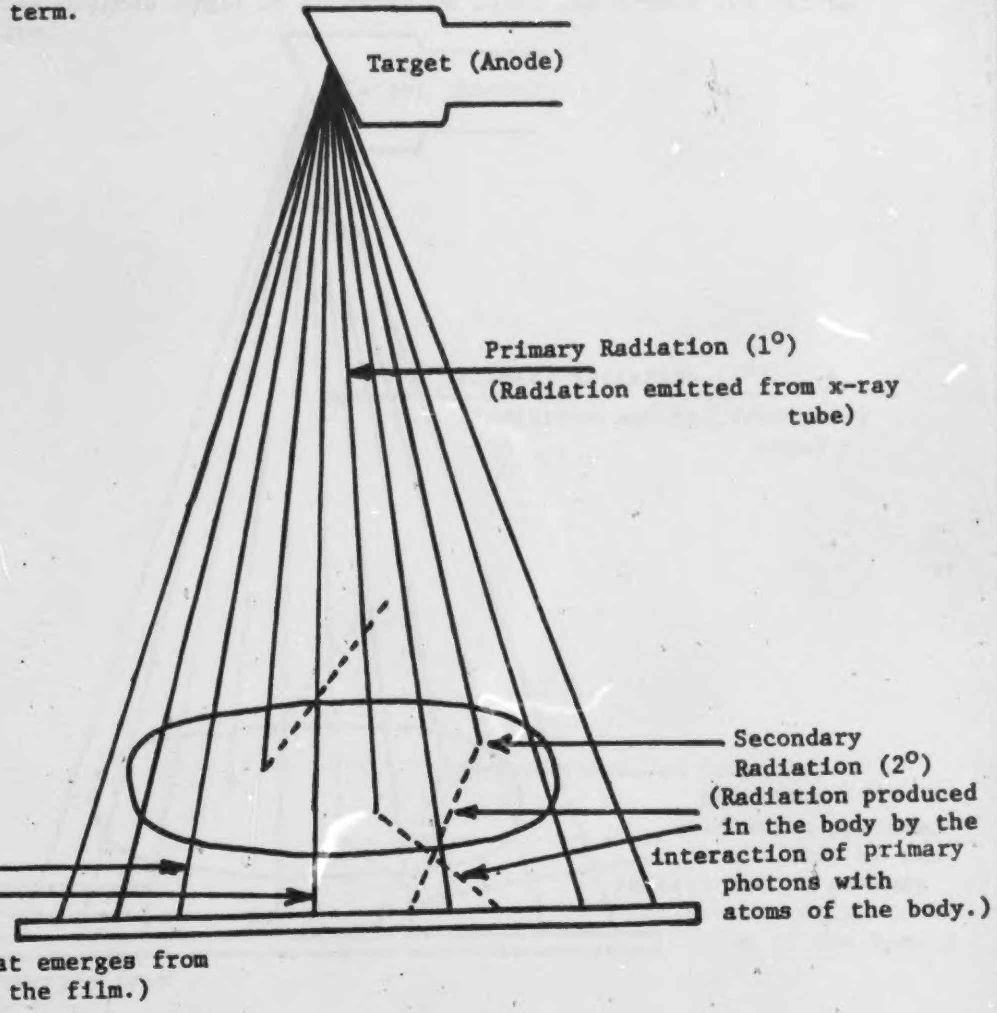
QUESTION: What primary forces are responsible for keeping electrons in orbit about the nucleus?

ANSWER: The law of centrifugal force and the law of electrostatics.

E. Target and Characteristics
    1. Tungsten
    2. Advantages
        a. High melting point (3370° C)
        b. High atomic number (74)

F. Types of Radiation

NOTE: Following diagram found in students GR label the arrows and define each term.


Target (Anode)
Primary Radiation (1°)
(Radiation emitted from x-ray tube)
Secondary Radiation (2°)
(Radiation produced in the body by the interaction of primary photons with atoms of the body.)
Remnant Radiation
(That portion of the primary radiation that emerges from the body and exposes the film.)

G. Methods of X-ray Production

1. Characteristic method

a. Incident high speed electron (1/3 - 1/2 c) strikes K or L shell electron of target and knocks it out of orbit.

b. Ion produced.

c. Outer shell electron drops into inner shell vacancy

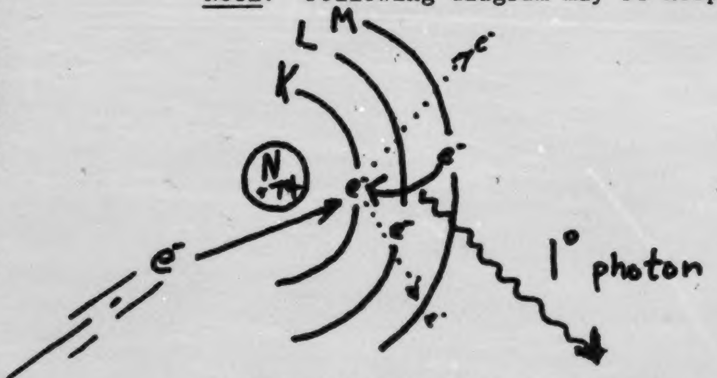
d. Energy emitted

e. Wavelength is characteristic of target material

f. Homogeneous beam

g. Accounts for 30% primary beam

NOTE: Following diagram may be helpful



QUESTION: What effect does atomic number have on the wavelength of characteristic radiation?

ANSWER: As the atomic number increases, the wavelength of radiation will decrease. This is why tungsten is used as a target. Also tungsten has a high melting point. Living organisms produce characteristic secondary radiation which is long in wavelength, thus most of it will be absorbed. This will be discussed a little later.

QUESTION: Is characteristic radiation homogeneous or heterogeneous in nature?

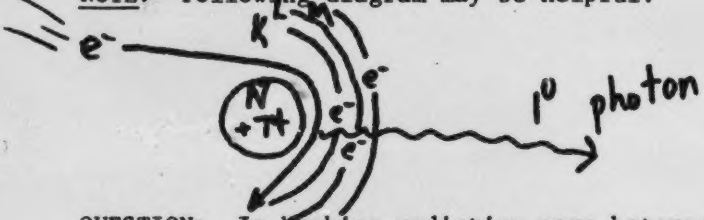
ANSWER: Characteristic production is very close to being homogeneous in nature. Only the K and L shells are capable of X-radiation production. The only other factor that affects wavelength is the distance between the shell of the replacement and the vacancy.

2. Bremsstrahlung (braking) method
    - a. Incident high speed electron passes close to nucleus of target atom.
    - b. Electron changes direction.
    - c. Energy emitted.
    - d. Heterogeneous production.

NOTE: Wavelength of photon produced depends on speed of electron and proximity to nucleus.

- e, Accounts for 70% of primary beam

NOTE: Following diagram may be helpful.



QUESTION: Is braking radiation more heterogeneous in wavelength than characteristic radiation?

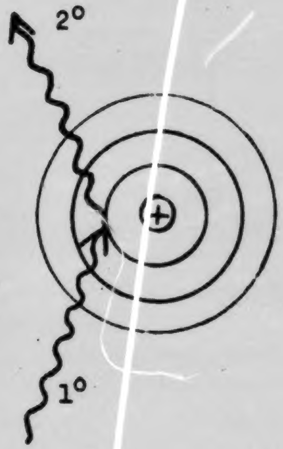
ANSWER: Yes, the wavelength is affected by the amount of deflection of the cathode electron. It also depends on the number of atoms the cathode electron is able to penetrate before it loses the energy given it by acceleration.

H. Methods of Secondary Radiation Production

1. Unmodified scatter

NOTE: Fill in diagram for students GR

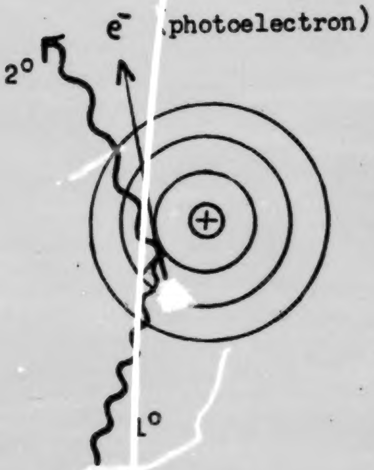
a. Primary photon strikes inner shell electron in body part.
b. Electron immediately leaves orbital and then returns.
c. Energy of same wavelength as incident photon reemitted but in different direction.



2. Photoelectric Effect

NOTE: Fill in diagram for students GR

a. Primary photon ejects inner shell electron from orbit.
b. Photoelectron.
c. Secondary radiation produced by characteristic method.



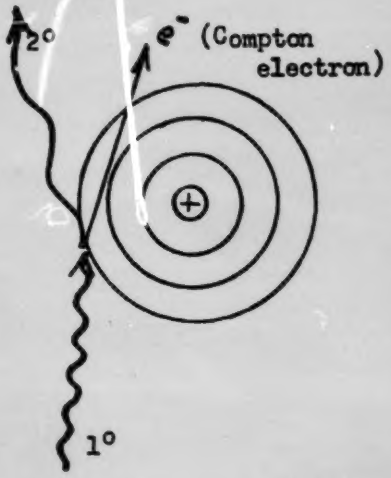
3. Compton Effect

NOTE: Fill in diagram for students GR

a. Primary photon ejects outer shell electron from orbit.

b. Compton electron.

c. Left over energy given off as lower energy secondary radiation.



ANNEX B
INSTRUCTIONAL AIDS

Slides

S 38-520-017-1	Slide showing two types of energy.
S 38-520-017-2	Slide showing relationship of potential energy to kinetic energy.
S 38-520-017-3	Example of relationship between potential and kinetic energy.
S 38-520-017-4	Slide showing forms of matter.
S 38-520-017-5	Example of forms of matter.
S 38-520-017-6	Slide showing atomic terms.
S 38-520-017-7	Slide showing typical atom as illustrated by the Bohr theory.
S 38-520-017-8	Slide showing atomic makeup.
S 38-520-017-9	Slide showing orbital shells around the nucleus.
S 38-520-017-10	Slide showing atomic differences (atomic number).
S 38-520-017-11	Slide showing atomic differences (atomic weight).
S 38-520-017-12	Slide defining an isotope.
S 38-520-017-13	Slide giving an example of isotopes.
S 38-520-017-14	Slide defining ionization.
S 38-520-017-15	Slide defining the Law of Electrostatics.
S 38-520-017-16	Slide defining centrifugal force.
S 38-520-017-17	Slide demonstrating relationship between energy and orbit (inner orbits).
S 38-520-017-18	Slide demonstrating relationship between energy and orbit (outer orbits).
S 38-520-017-19	X-ray Production, slide No. 1.
S 38-520-017-20	X-ray Production, slide No. 2.
S 38-520-017-21	X-ray Production, slide No. 3.

ACADEMY OF HEALTH SCIENCES, U.S.ARMY
Division of Medicine and Surgery
X-ray Branch

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*IM 38-520-017
016

Atomic Structure

In our atomic age nearly everyone knows something about atomic structure, but a proper knowledge of electricity and the formation of X-rays requires better than average concepts of the makeup of an atom. The X-ray Specialist is required to know how X-rays are produced and why they produce harmful effects to living organisms. When he understands this he will be able to produce a film of superior quality yet keep the patient dosage at a lower level.

Energy is defined as "the ability to do work". There are two main types of mechanical energy, potential and kinetic. Potential energy can be thought of as energy at rest. This means that an object will expel energy if an external force is applied to set this object in motion. Kinetic energy is energy of motion. A car travelling down the highway possesses kinetic energy as long as it is moving. When it stops it possesses potential energy. As an object loses potential energy, it gains kinetic energy. The opposite is also true.

Matter is defined as anything that occupies space. There are three forms of matter; solids, liquids and gases. Using the example of water, one could compare the molecular action of these three states and he would find that when water is frozen the molecules slow down in movement. However, when water is heated the molecular action will increase. This molecular action can also be thought of as an energy value. This would indicate that liquids possess a higher energy value than solids, and gases possess a higher energy value than liquids.

Terms that we will mainly be concerned with are the atom, molecule, and the element. The atom can be defined as the smallest particle of matter. A molecule may be defined as the smallest particle of a substance that has all of the properties of that substance. An element may be defined as a substance in its pure form.

The most widely accepted theory of atomic structure and also the theory which we will accept is the Bohr theory. In 1913 Niels Bohr stated that an atom was much like our solar system in which we live. The atom has a nucleus around which smaller bodies orbit. These smaller bodies are like the planets orbiting around the sun in our own solar system. The nucleus of an atom is made up of protons and neutrons. A proton is a small body with a positive charge on it. It is about 1,838 times larger than the tiny electron bodies orbiting around the nucleus. The nucleus also contains neutrons. These are about the same size as the proton but they do not have an electrical charge on them.

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*This instructor's manuscript supersedes IM 38-520-017, 010

Both the protons and the neutrons impart mass to the nucleus, but only to protons contribute positive charges to the nucleus. Other nuclear particles have been discovered more recently; however, these will not be considered in this class.

An orbit is a path around the nucleus in which electrons move in continual motion around the nucleus. Depending upon the type of atom, there can be as many as seven different orbits to a single atom. These shells are labeled in alphabetical order starting with K and ending with Q.

All atoms contain the same essential parts but not all atoms have the same number of these parts. There are two ways to determine atomic differences--by atomic number and by atomic weight. The atomic number is defined as the number of protons in the nucleus. The atomic weight is the number of protons and neutrons in the nucleus. Every element has an atomic makeup that differs either in atomic number or weight. Therefore, both can be used as a means of identification.

An isotope is defined as an atom of the same element that differs in atomic weight but has an identical atomic number. An example of this is the atom of hydrogen. This atom contains one proton in the nucleus and one electron orbiting about the nucleus. If one neutron is added to the nucleus, the atomic weight is changed but the atomic number remains the same. The atom now becomes an isotope of hydrogen and is called deuterium. If another neutron is added the isotope is again changed and now is called tritium. It is possible for some elements to have a large number of isotopes. Some of these isotopes are radioactive and are called radio-nuclides. These are used for treatment of cancer. The most common radio-nuclide used for therapy is Cobalt 60.

When an atom becomes electrically unbalanced it is said to be ionized. In an electrically stable atom, there will be a balance between the number of protons and electrons. If an electron is added, the atom will have one more negative body than positive bodies. This atom is considered to be negatively ionized. If an electron is removed from an electrically stable atom, the atom then becomes a positive ion as it now has more protons in the nucleus than electrons in orbit. Ionization is the first step to radiation production.

Atomic cohesive force is considered to be the force that holds the electrons in orbit around the nucleus. The law of electrostatics states that like charges will repel and unlike charges will attract each other. The nucleus of an atom is positively charged. Electrons in orbit are attracted to the nucleus by the difference in the type of charge. The electrons in orbit are moving at a very high velocity. However, all electrons have the same velocity. The shells closer to the nucleus have a smaller diameter and the angle of that shell will be greater than the outer shells. Since the electrons are traveling at the same velocity, it is necessary to consider the effect of centrifugal force. This can be defined as the force that tends to keep a moving object traveling in a straight line. It can be said that the greater the angle of deflection, the greater the centrifugal force. In reference to the shells of an atom, the inner shells require the electrons to rotate in a more acute angle. Because of this there is more centrifugal force on the electron. However, this is counterbalanced by the closeness of the two unlike charges, and thus a greater attraction between the two unlike charges. In short, the greater the distance between the electron and the nucleus, the less the attraction, and the less the centrifugal force. The closer the electron is to the nucleus, the greater the attraction and the greater the centrifugal force.

This brings up another interesting area--that of energy vs. orbit. The inner electron shells are bound tightly into orbit as the attraction is very great and the centrifugal force is equally great. These two opposing forces determine the amount of force needed to "knock" an electron out of orbit. The outer orbits are not attracted as much because of the greater distance from the nucleus and they do not possess as much centrifugal force because of the angle of its shell. Consequently, the electron is not bound to the orbit as tightly.

Basing the energy value of different shells on the basis of negative potential, it can be said that the inner shells are low energy shells and the outer shells represent high energy shells. It is best to use the term "negative potential" because a certain amount of energy is needed to overcome the cohesive force of an electron shell. In order to release an electron from the K orbit it requires a force of 70 KEV. An electron from the L orbit requires about 11 KEV to dislodge it. This is the amount of force needed to bring the dislodged electron back to zero potential. Therefore, the greater the force needed to dislodge an electron, the lower the energy value of its orbit. The energy of the X-ray produced when an electron replaces this vacancy, is dependent upon which orbit the replacement electron comes from. If the vacancy is created in the K orbit and the replacement electron comes from the L orbit, the electron coming from an outer orbital electron must give up energy when moving into an inner orbit. In this case the L orbit is represented by 11 KEV and the K orbit is represented by 70 KEV. Both are expressed in negative potential. The resultant photon produced will be equivalent to 70 KEV minus 11 KEV, or 59 KEV. This type of radiation production is termed characteristic production. Elements not having many orbital shells are not capable of producing X-rays of short wavelength. Therefore, we say that this type of radiation production is characteristic of the element that it is produced from. This type of production accounts for approximately 30 percent of all X-radiation produced within an X-ray tube.

The primary method of X-ray production takes place by the Bremsstrahlung effect. This effect is also known as the "braking effect." Electrons that are used for bombardment of the target, do not always interact with the target atoms. As an electron passes through a target atom, it will be deflected towards the nucleus by the strong attraction of unlike charges. As this deflection takes place the electron will give off some of its kinetic energy in the form of X-radiation. There are two factors that control the energy of the photon--the speed of the electron, and the distance it passes from the nucleus. This same electron can leave one target atom and pass through another, still producing X-radiation but with a longer wavelength. A single electron can undergo as many as 10,000 different interactions before it loses the energy given it by acceleration. This type of production will yield a wide range of wavelengths. Therefore, we call the X-ray beam a heterogeneous beam.

When a photon penetrates matter, it could pass through the object without a single interaction with the substance. However, it is likely that not all of the radiation will do this. When an X-ray strikes an electron of the object, one of three things can happen. If the photon striking the electron does not strike the electron directly in the middle, the photon will be deflected at an angle off of the electron. This is called unmodified scattering because the photon loses very little energy due to this interaction. Therefore, the photon remains relatively unchanged.

If the photon strikes an electron head-on, all of its energy is absorbed by the electron. The electron now has sufficient energy to dislodge itself from the orbital shell. The electron moves out of the atom and is called a photoelectron. We now must replace the vacancy created. If the vacancy is in either the K or L shell, there will be X-radiation produced. However, this radiation is produced by a photon rather an an electron. This is called secondary characteristic production. Again this radiation will be characteristic of the element it is produced from.

If the photon striking the atom electron has sufficient energy, it can strike and dislodge the atom electron, yet not be absorbed by the electron. In this case we still have our primary photon and we have dislodged an electron in the K or L shell. However, the primary photon has now decreased in its energy value. Again when the vacancy is replaced there will be secondary characteristic production. This effect is called the Compton effect.

It is necessary to know the action of X-rays and how they affect film quality. Understanding the concept of production determines the method of improving the quality of useful radiation or of controlling unwanted radiation which is harmful to the patient and reduces film quality.

Mr. Blair Bryant

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*LP 38-520-003
124

Introduction to Electricity (2 hours)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES: TM 8-280
Selman, Joseph. The Fundamentals of X-Ray and Radium Physics. 5th ed. Springfield, Ill: Charles C. Thomas, Pub. 1972 pp 54-69.

STUDY ASSIGNMENT: Before class read TM 8-260, pp. 4-1 thru 4-2, para 4-1 thru 4-5

STUDENT UNIFORM AND EQUIPMENT: TM 8-280

TOOLS, EQUIPMENT, AND MATERIALS: GR 38-520-001-1 issued at beginning of first week of class.

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Chalk, chalkboard, eraser, battery, oscilloscope

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Lecture (2 hours)

I. INTRODUCTION (5 min)

A. Opening Statement: If all electricity suddenly ceased to flow, society would come to a standstill. The versatility of America and all other industrialized nations depends upon the production of electrical current. Electricity is also the foundation of the X-Ray machine. Therefore, the basic laws of electricity must be understood by the X-Ray student.

B. Objectives

1. Identify or State:

a. The four factors which affect the electrical resistance of conductors.

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*This lesson plan supersedes LP 38-520-0030, 070

313

b. The type of current (AC, uniform DC, pulsating DC) represented when given a diagram of that current or a description of how it flows.

2. Define the terms voltage, current, resistance.

3. Match the terms voltage, current and resistance with their respective units.

4. Convert: volts to kilovolts; kilovolts to volts; amperes to milliamperes; milliamperes to amperes.

C. Class Procedure and Lesson Tie-in

None

II. EXPLANATION (75 min)

NOTE: Refer to Annex A for completed outline. (Students using GR 38-520-001-1 have major underlined headings filled in and must complete their notes as per Annex A).

Questions From Students

III. SUMMARY (10 min)

A. Review of Main Points

1. Types of current

a. Uniform D.C.

b. Pulsating D.C.

c. A.C. current

2. Basic electrical concepts

a. Voltage

b. Current (amperage)

c. Resistance

B. Closing Statement: The understanding of kilovoltage and milliamperage is essential in order to understand their effect on the X-Rays produced in the tube. This knowledge will help in your understanding the functions of variable resistances, choke coils, transformers, etc., which are used in the X-Ray machine.

ANNEX A
INSTRUCTIONAL AIDS

A. Electricity.

1. Effect produced by having excess or deficiency of charges of one sign in an area.

2. Effect produced by charges moving.

B. Fundamental Law of Electrostatics.

1. Like charges repel.

2. Unlike charges attract.

C. Types of Electricity.

1. Static

a. Definition - charges at rest.

b. Example

1) Combing hair

2) Taking off sweater

3) Walking across carpet

4) Lightning

QUESTION: What do all these examples of static electricity have in common?

ANSWER: They're all produced by friction.

2. Dynamic

a. Definition - charges in motion

b. Types

1) Direct Current (D.C.)

a) Definition - charges (electrons) flowing in only one direction.

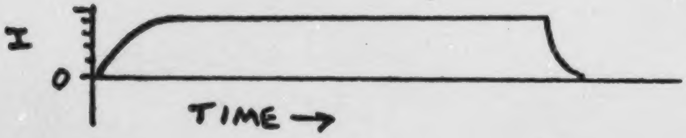
315

b) Types

(1) Uniform

(a) Charges smoothly flowing with no surges except when turned on or off.

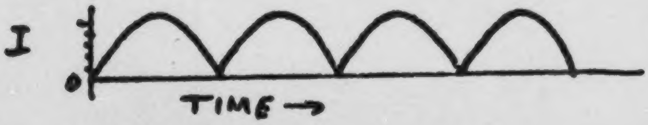
NOTE: Demonstrate uniform D.C. with battery and oscilloscope. Also make following diagram to show uniform D.C.



(2) Pulsating

(a) Charges continually change speed.

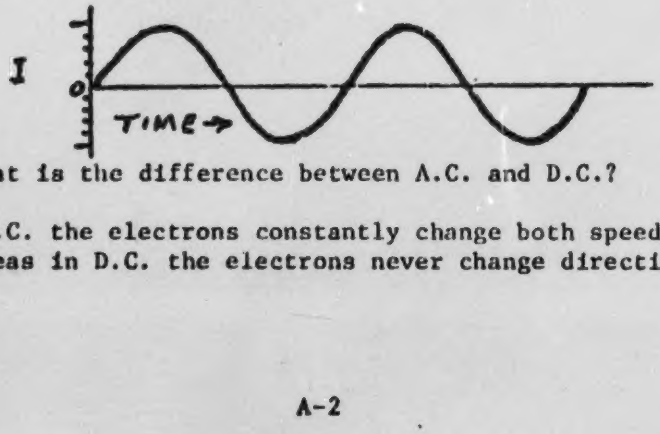
NOTE: Pulsating D.C. is used in X-Ray production. The following diagram shows pulsating D.C.



2) Alternating Current A.C.

a) Definition - charges (electrons) change both speed and direction.

NOTE: The sine wave is used to illustrate A.C.



QUESTION: What is the difference between A.C. and D.C.?

ANSWER: In A.C. the electrons constantly change both speed and direction whereas in D.C. the electrons never change direction.

316

D. Three Basic Electrical Concepts

1. Voltage

    a. Definition - push or pull on the electrons

    b. Synonyms

        1) Potential

        2) Potential difference

        3) Pressure (electrical)

        4) Electromotive force (E.M.F.)

    c. Unit of measure - volt

NOTE: Kilovolt (kV) is used commonly in X-Ray. One kV = 1000 volts. Give students appropriate practice converting volts to kilovolts and vice versa.

    d. Measuring instrument

        1) Voltmeter

        2) Kilovoltmeter

    e. Sources

        1) Chemical (battery)

        2) Mechanical (generator)

        3) Solar

        4) Atomic

2. Current

    a. Definition - flow of electrons

328

b. Unit of measure - Ampere (A)

NOTE: Milliamperage (mA) is commonly used in X-Ray. One mA = 1/1000 amperes Give students appropriate practice converting mA to amperes and vice versa.

c. Measuring instrument

1) Ammeter

2) Milliammeter

3. Resistance

a. Definition - opposition to flow of electrons

b. Unit of measure - Ohm

c. Factors controlling resistance

1) Type of material

a) Conductor - usually metallic

b) Non-conductor (insulator) - usually non-metallic

2) Length of wire

NOTE: Resistance increases as wire length increases.

3) Diameter of wire

NOTE: Resistance increases as diameter of wire decreases.

4) Temperature of wire

NOTE: Resistance may increase as wire temperature increases.

QUESTION: What are at least three factors which affect resistance?

ANSWER: Type of material, temperature, length and diameter of wire all affect the resistance.

ACADEMY OF HEALTH SCIENCES, US ARMY
MEDICINE AND SURGERY DIVISION
X-RAY BRANCH
FORT SAM HOUSTON, TEXAS 78234

*IM 38-520-003
124

Introduction to Electricity

If all electricity suddenly ceased to flow, society would come to a standstill. The versatility of America and all other industrialized nations depends upon the production of electrical current. Electricity is also the foundation of the X-Ray machine. Therefore, the basic laws of electricity must be understood by the X-Ray student.

In discussing electricity it is convenient to separate the electricity into two types: static and dynamic.

Static electricity is electrical charges at rest; that is, it is not moving. A person finds many examples of static electricity in daily life. When synthetic fabrics are used in clothing a crackle is often heard, especially during the winter. This is due to the static electricity. By rubbing a plastic rod with cat fur it is found that electrons are removed from the fur and collect on the rod to make the rod negatively charged. The rod will then attract small bits of paper, hair, etc. If a glass rod is rubbed with a piece of silk the rod will pick up a positive charge. Similar effects are shown but it can be shown that the charge on the plastic rod and glass rod are oppositely charged.

It may also be shown that charges from either the plastic or glass rods will repel each other, while charges from the glass rod will attract those from the plastic rod. This illustrates the fundamental law of electricity which states that like charges repel; unlike charges attract.

Dynamic electricity are electrical charges in motion. There are two fundamentally different types of dynamic electricity--direct currents and alternating current.

Direct current is electricity which flows in only one direction and may occur in either of two ways. A direct current which is smoothly flowing and which has no surges except when turned off or on is called a uniform direct current. It is, however, possible to have a current in which the direction of flow is not changed but in which the speed of the electrons are constantly changing. This type of current is known as pulsating direct current.

Alternating current is defined as electricity which changes both speed and direction. The sine wave is commonly used to designate this type of current.

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*This instructor's manuscript supersedes IM 38-520-003, 070

Any science is based on categorization and measurement. Electricity is no exception. Electrical factors may be categorized according to the following basic concepts—voltage, current, and resistance.

Voltage is the pressure or "push" which makes electricity move. Voltage is obtained from the separation of positive and negative charges. The greater the number of charges separated the greater is the voltage or "push" that is produced on the electrons. Voltage is also termed electromotive force (abbreviated e.m.f.), potential or potential difference referring to potential energy of separated positive and negative charges. The unit of measurement of voltage is the volt and the instrument which is used to measure the amount of voltage is the voltmeter. A kilovolt is a unit of measurement of voltage just 1,000 times as large as the volt.

Electrical current is a flow of charged particles. In most familiar electrical devices the charged particles are electrons and electrons alone. Except for the flow of current through gases and liquids, positively charged ions do not move to produce an electric current flow.

The unit of measurement of the current is the ampere and the instrument used to measure the amount of current is the ammeter. The ampere is numerically equal to a rate of flow of approximately 6,300 quadrillion electrons passing a point per second. The ampere is a rate of electron flow and does not measure the quantity. The milliampere is a rate of electron flow equivalent to 1/1,000 ampere.

Electrical resistance is the property that all materials have in hindering or restricting the flow of electrons. The unit of measurement of resistance is the ohm. The amount of electrical resistance is dependent upon several factors. The type of conductor is highly important to the amount of electrical resistance. Some materials will allow an electric current to pass with great ease, while others will permit a current to flow only under excessive electrical pressures. In general, the metals are good conductors of electricity, while the nonmetals are poor conductors of electricity.

The dimensions of a material also greatly affect the flow of current through it. A long conductor for example has more atoms to hinder the flow, so the current finds more hinderance or resistance than in a short conductor. A thick wire allows electrons to spread out more and allows a current to flow much more easily than a thin one.

One other factor will influence electrical resistance, but to only a small degree for most substances—this is temperature. In general, an increase in temperature will slightly increase electrical resistance; but this is not true of all substances.

320

The understanding of kilovoltage and milliamperage is essential in order to understand their effect on the x-rays produced in the tube. This knowledge will help in your understanding the functions of variable resistances, choke coils, transformers, etc., which are used in the x-ray machine.

332

ACADEMY OF HEALTH SCIENCES
MEDICINE AND SURGERY DIVISION
X-RAY BRANCH

LP 38-520-006
048

Errata Sheet No 1

Radiation Protection (2 hours)

LP 38-520-006, 018, is changed as follows:

A. Change the REFERENCE pertaining to Selman, J., The Fundamentals of X-Ray Protection to read:

Selman, J. The Fundamentals of X-Ray Protection. Springfield: Thomas, 1972, 5th ed. Chapter 23, pp 457-467.

B. Add to INSTRUCTIONAL AIDS:

Dosimeter, six copies of DD Form 1141 completed.

C. Add to Objectives:

6. Calculate the maximum permissible dose (MPD) when given the age of the technician.

D. Add the following to para B2a, page 3 (Dosimetry): (i.e., the amount of radiation which produces a certain amount of ions in a specific amount of air.)

E. Add the following to para B2b, Page 3 (Dosimetry): (i.e., the amount of radiation absorbed in a gram of any substance, e.g., body tissue.)

F. Add the following to para B2d, page 3 (Dosimetry): (i.e., the dose converted to damage effect in human tissues; rads X QF = rems.)

G. Add the following paragraph to para B3a(2), page 4 (Dosimetry):

(f) The technician is required to wear a monitoring device such as the photographic film packet as required by AR 40-14, para 6c(1).

IM 38-520-006, 048, is changed as follows:

Add to paragraph 3, page 3, the following:

According to AR 40-14 (para 6c(1)), a technician is required to wear a monitoring device and in most cases the photographic film packet meets the requirement. A technician needs to bear in mind that he has the primary responsibility to use a monitoring device, one which he wears at all times when he works around ionizing radiation.

ACADEMY OF HEALTH SCIENCES *LP 38-520-006
MEDICINE AND SURGERY DIVISION 018
X-RAY BRANCH

Radiation Protection (2 hours)

COURSES PRESENTED: 313-91P10, X-Ray Specialist

PLACE: Classroom

REFERENCES:

TM 8-280, Chapter 3.
TB MED 62 (for reference to equipment regulations).
Andrade, E. N. da C., *An Approach to Modern Physics*, Doubleday, Anchor, London, 1956.
Bushong, Steward C. *Radiologic Science for Technologists*. St. Louis: C. V. Mosby Company, 1975, page 40.
Hendee, Chaney, Ross. *Radiological Physics, Equipment and Quality Control*. Chicago: Year Book Medical Publishers, Inc., 1977.
Selman, J. *The Fundamentals of X-Ray Protection*. Springfield: Thomas, 1972, 5th ed. Chapter 23. p. 457 - 467.
Semat and White. *Atomic Age Physics*. New York: Holt, Rinehart, and Winston, 1967.

STUDY ASSIGNMENT: Read TM 8-280, Chapter 3, before class. Study GR 38-520-001-1A after class.

STUDENT UNIFORM AND EQUIPMENT: Not applicable

TOOLS, EQUIPMENT, AND MATERIALS: TM 8-280, GR 38-520-001-1A

PERSONNEL: One instructor, 91P2H/91P3H/91P4H

INSTRUCTIONAL AIDS: Chalk, chalkboard, and eraser; Victoreen R meter, pocket dosimeter, thimble for R meter, six pre-opened film badges.

TROOP REQUIREMENTS: None

TYPE OF INSTRUCTION: 1st and 2d hours (lecture)

FIRST THROUGH SECOND HOURS:

I. **INTRODUCTION** (5 min)

A. Opening Statement: As X-ray technicians, you will be closely in contact with ionizing radiation. Beyond X-radiation, you may encounter other types of radiations. Since all ionizing radiations are invisible, the potential for misuse, which can lead to overexposure, is always possible. To protect everyone concerned is

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This lesson plan supersedes LP 38-520-025, 050.

our first and most important duty. In this lecture you will be taught the use of the film badge and how to calculate the maximum permissible radiation dosage.

B. Objectives

1. State two types of particulate radiation sources and two types of electromagnetic radiation sources.

2. Identify the definitions of the terms "rad," "rem," and the roentgen.

3. State the name of the radiation monitoring device which provides a record of ionizing radiation received by the wearer.

4. List four types of radiation detection devices commonly used for the detection of ionizing radiation.

5. Identify your responsibility to utilize a monitoring device when you work around or near ionizing radiation.

C. Class Procedure and Lesson Tie-in: This is the first and second hours of five hours given on the subject of radiation protection

A. Radiation

1. Definition: Any kind of particle or wave which leaves a point source and radiates outward in all directions (light and X-rays are forms of radiation)

2. Sources of Exposure: Ionizing Radiation

a. Particulate (or corpuscular)

(1) Alpha: Characteristic

(a) A helium nucleus (He^{++})

(b) A speed of 9-18,000 mi/sec

(c) Stopped by paper or 1" of air

(2) Beta: Characteristics

(a) A high speed electron from the atomic nucleus

(b) A speed of 100,000 to 186,000 mi/sec

(c) Stopped by 1-2 cm of tissue or 10-100 cm of air

b. Electromagnetic

(1) X-rays: Characteristics

(a) Produced in X-ray tube

(b) Beam or ray traveling the speed of light

(c) A wavelength between .01 to about 120 Å

(2) Gamma: Characteristics

(a) Produced in the atomic nucleus

(b) Wavelength of between 4Å and 10^{-3}Å

(c) Can penetrate a plate of lead 10 inches thick

B. Dosimetry

1. Definition: The measurement of exposure of ionizing radiation

2. Most common units

a. Roentgen(r) (adopted 1937): Definition: is equal to the radiation intensity that will create 2.08 x 10^9 ion pairs in a cubic cm of air; that is, 1 r = 2.08 x 10^9 ion pairs/cm^3

b. Radiation absorbed dose (adopted 1953): Definition: is equal to 100 ergs per gram

c. Roentgen equivalent man (adopted 1928): Definition: is a unit of dose equivalent which is numerically equal to the dose in rads multiplied by appropriate modifying factors, such as RBE (or QF)

d. Relationships of units in diagnostic X-ray energy region: 1 r = 1 rad = 1 rem

3. Monitoring devices

a. Photographic film (film badge)

(1) Construction

(a) Film packet (two films of different sensitivity)

(b) Plastic holder

(c) Window

(d) Aluminum

(e) Copper

(f) Cadmium and tungsten

(2) Usage

(a) Worn on trunk area

(b) Worn for a four to five-week period

(c) Exchanged and sent to Blue Grass Army Depot (Lexington, Kentucky)

(d) Use DD Form 1141 report with two entries

1 Dose for monitoring period

2 Cumulative dose

(e) Advantages and disadvantages

1 Permanent record

2 Dose is read only every 30 days

b. Ionization chambers: (in r)

(1) Victoreen R meter (reads in mr)

(2) Pocket dosimeter (reads in mr)

(3) Direct reading dosimeter (mr)

c. Others

(1) Thermoluminescence desimeters (TLDs): Lithium fluoride crystals store energy and re-emit as light when heated

(2) Chemical dosimetry: Some chemicals change colors upon exposure to X-radiation

(3) Calorimetry: A measurement of heat produced by X-radiation

4. Maximum permissible dose (MPD)

a. Definition: The amount of radiation a normal human being may receive without any harmful effects to himself becoming evident within his lifetime

b. Formula: MPD = (N - 18) x 5

   (1) Only used for those 18 years old and older

   (2) Maximum is 5 rems per year and 1.25 rems/quarter

   (3) An 18-year-old can receive 1.25 rems per quarter up to a maximum of 3.0 rems per year. (See AR 40-14, para 6a(7))

QUESTION: What type of radiation monitoring device provides for permanent record of exposure to radiation?

ANSWER: The film badge.

QUESTION: What relationship is there between roentgen, rads, and rems in the diagnostic X-ray energy range?

ANSWER: They are all approximately equal to 1. 1 rad = 1 roentgen = 1 rem.

C. Questions from Students

III. **SUMMARY** (5 min)

A. Review of Main Points:

1. Radiation: Definition and sources of exposure

2. Dosimetry: Definitions, common units, monitoring devices, and maximum permissible dose (MPD)

B. Closing Statement: In the Army environment you may, at some time or another, encounter more than one type of hazardous ionizing radiation. As an X-ray technician, it will be your responsibility to monitor this radiation by carrying a film badge or similar device whenever you work near or in the vicinity of ionizing radiation. At some time in your career, it may also be necessary for you to calculate the maximum permissible dose allowed for individuals who work by ionizing radiation. Hopefully, this lecture has helped you see the need of understanding the types of invisible and hazardous radiation around you and how you as a technician can monitor it for your own safety.

INSTRUCTIONAL HOURS

Number of instructors required - - - 1

Primary hours	2
Secondary hours	0
Total	2

ACADEMY OF HEALTH SCIENCES *IM 38-520-006
MEDICINE AND SURGERY DIVISION 018
X-RAY BRANCH

Radiation Protection

As X-ray technicians you will be closely in contact with ionizing radiation. Beyond X-radiation, you may encounter other types of radiations of a potentially hazardous nature. Since all ionizing radiations are invisible, the potential for misuse, which can lead to overexposure, is always possible. To protect everyone concerned is our first and most important duty. In this lecture you will be taught the use of the film badge and how to calculate the maximum permissible radiation dosage.

Radiation may be defined as any kind of particle or wave which leaves a point source and radiates outward in all directions. For example, light and X-rays are forms of radiation. The radiation which we, at some time or another, can come in contact with is either particulate or electromagnetic in nature. If it ionizes living cells, we call it ionizing radiation. Any subatomic particle in motion, likewise, is capable of causing ionization.

Particulate or corpuscular radiation may be alpha or beta. Alpha radiation is a helium nucleus which is composed of two protons (He^{++}). These helium nucleuses travel at a speed of from 9 to 18,000 mi/sec. The alpha particle has a charge of 3.19×10^{-19} coulombs or just about twice the charge of an electron, but opposite in sign - that is, positive, where the electron is negative. The mass of the alpha particle is 6.62×10^{-24} grams. This is four times the mass of the hydrogen atom. Alpha particles are stopped by a sheet of ordinary paper and have an approximate range of up to .1 mm in soft tissue. Because of their relatively large mass (compared to other radiations) and because of the fact that they carry two positive charges, alpha particles are strongly ionizing. This is when they encounter other atoms, they ionize them readily in large numbers.

Beta particles are fast moving electrons ejected by certain radioisotopes from the nucleus and usually carry a single negative charge. They cause significant ionization in tissues where they are, for the most part, absorbed. Beta particles differ from alpha particles in both mass and charge. They are light particles with an atomic mass number of zero. Once emitted from a radioisotope, beta particles traverse through the air with a specific ionization of several hundred ion pairs per cm. Their range is longer than that of an alpha particle. Depending upon its energy, a beta particle may traverse 10 to 100 cm of air and about 1 to 2 cm of soft tissue. Once a beta particle has transferred all of its energy, it comes to rest and combines with an atom deficient in electrons.

Roentgen rays are one type of electromagnetic wave, traveling with the same constant speed of light, 186,000 mil/sec (3×10^{10} cm/sec) in a vacuum. X-rays are produced whenever electrons strike a target such as tungsten.

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*This instructor's manuscript supersedes IM 38-520-025, 050.

When the electron stream encounters the tube target, X-rays are produced in two ways. If the electron misses the electron in the inner shell tungsten atom, we say that braking occurs, thus the name bremsstrahlung radiation. With each different deceleration, a corresponding amount of kinetic energy is converted to energy or X-rays. An electron with a sufficient energy can also collide with an inner shell electron, ejecting it from its orbit. This energy emitted is in the form of an X-ray called characteristic radiation. These rays are highly penetrating invisible rays belonging to the general category of electromagnetic waves. Since they are electrically neutral, they cannot be deflected by electrical or magnetic fields. They occur in a wide range of wavelengths from about .04 Å to more than 1000 Å; however, their useful range in diagnostic radiography is from .1 Å to .5 Å.

Another electromagnetic wave, which is a photon, is the gamma ray. Gamma rays travel at the speed of light and are much more penetrating than alpha or beta radiation. Gamma rays are physically indistinguishable from X-rays and their only difference being in their point of origin. Gamma rays are made in the nucleus, whereas X-rays are produced in the shells of the atom. In extreme case, the gamma rays have wavelengths of less than ten thousand millionth of a centimeter. Naturally, gamma rays are very penetrating, even after they have passed through a plate of lead ten inches thick. Generally, the gamma wavelength is indicated as being between .01 and 1.5 Å.

There are several detectors available that can be used to help observe the radiation associated with any work in X-ray technology. The measurement of radiation by these devices of the ionizing radiation is called dosimetry, and the radiation exposure is the measure of the amount of ionization produced by X-rays or gamma rays in air. The unit of measurement is the roentgen and is defined as the amount of X or gamma (γ) radiation that produces a charge (of 1 esu) in 1 cc of air (at standard temperature and pressure). The ions created by the secondary radiation are included as part of the charge in the definition of "The Roentgen." The roentgen was adopted in 1937 and is abbreviated simply R. Since only the radiation actually absorbed in the patient is responsible for a biologic change and since the emission will differ from what the patient actually absorbs, the "Rad" is used. The Rad, or unit of radiation absorbed dose, is the amount of energy deposited by ionizing radiation in the irradiated material at the place of interest.

This definition applies to any type of radiation (X-rays, gamma rays, beta particles) and to any kind of matter including tissues. Technically, the Rad is defined as an energy absorption of 100 ergs per gram. However, film badges, which are personnel monitoring devices, analyze radiation in rems or roentgen equivalent man. The rem is used since some types of radiation produce more damage than X-rays. The "rem" accounts for these differences in biological effectiveness.

What is the relationship of the unit of absorbed dose - the rad - to the unit of exposure - the roentgen - to the rem - the radiation equivalent man? The absorbed dose in soft tissues (of 100 kVp to 2 Mv) exposed to 1 R is approximately 1 rad (with an error of only a few percent) which in turn is also about 1 rem. In any case, the one-to-one-to-one conversion is sufficiently accurate in radiotheraphy of soft tissues. Therefore, 1 Rad = 1 roentgen = 1 rem (in X-ray).

Radiologists and technicians are occupationally exposed to radiation. In order to monitor the quantity of radiation they receive, three to six types of personnel monitors can be used to measure the amount the worker may be receiving. These personnel monitors offer no protection in themselves against radiation exposure; they are simply used as an indicator of the exposure to the wearer.

The photographic film badge came into general use about the mid-1940's and has been widely used in diagnostic radiology since then due to their lack of expense and value as a record. The film badge is especially designed to allow two small pieces of film similar to dental packets to be sandwiched between metal filters inside a plastic holder. The film may contain only an X-ray sensitive emulsion or it may be sensitive to X-ray, gamma rays, and beta particles. Special films are available to detect and measure neutrons.

The film badge is generally worn on an area of the body expected to receive the highest exposure such as the chest. The film badge should not be carried in a pocket or behind any object, such as, combs, cigarettes, or tags as they tend to absorb radiation and reduce density reaching the film. (If an apron is worn, then the film badge is inside the apron.) The film badge is worn on the individual for a period of four to five weeks. When not in use, film badges should be stored in a radiation free area. At the end of four to five weeks, the film badge is sent to the Blue Grass Army Depot in Lexington, Kentucky. The individual's record, DD Form 1141, has two entries of importance: (1) the dose for a period of monitoring (usually 30 days), and (2) cumulative dose (the total dose which the carrier has accumulated in his occupational history). Film badge programs are designed to provide radiation workers with a means for detecting accidental exposure to radiation in order that they can be provided with medical treatment if necessary. The advantage to the film badge is that it offers a convenient, reliable, and inexpensive monitoring device. Unfortunately, the dose is checked only once every four to five weeks so that if an exposure has been accidental or if it was the result of a deliberate act or through a careless act occurring in the first few days of the four- to five-week period, then the overexposure is not known until the four- to five-week period has been completed and film sent to the Army Depot. Some of the most common causes of overexposure are: (1) improper storage of the film badges, (2) failure of the individual to use protective shielding, (3) improper working techniques, (4) inadequate or defective radiation shielding, and (5) unintentional wearing of film badge while receiving diagnostic or therapeutic X-rays.

Since none of the five senses can detect the presence of radiation, the ionization ability of the X-ray is used either chemically or electrically to detect X-rays. An example of the electrical type is shown in the ionization chamber. By applying a difference in potential across the encased chamber to cause a movement of free electrons, the rate of current flows reflects the amount of radiation striking the chamber. The chamber is calibrated in roentgens. Several examples of instruments used to measure radiation in this manner are the pocket dosimeter, the direct reading dosimeter, the Victoreen R meter, and the Geiger-Mueller Counter. For practical purposes (due to the bulkiness of the ionization chamber), a thimble chamber was developed by

H. Fricke and O. Glasser and incorporated in a box shaped Victoreen R meter, which is about the size of an old style Kodak box camera. While the Victoreen R meter is sufficiently accurate for clinical work and is convenient and simple to use, its accuracy holds only for a limited range of kilovoltage. A pocket ionization chamber is a pencil-shaped device similar in principle to a charged electroscope. When exposed to radiation, the charge of the chamber is partially neutralized. Pocket dosimeters are useful for recording doses over a relatively short time period and are worn routinely by persons working near radiation sources, such as radioisotope production facilities.

The direct reading dosimeter is similar to the pocket dosimeter except that a dosage can be read directly from the cartridge itself. The pocket and direct reading dosimeter have a limited range, however, and should the exposure to the individual exceed the range of the dosimeter (the range is about 0 to 200 mr), the precise level of exposure would never be known. Pocket dosimeters are fairly expensive and can be easily damaged. The Geiger-Mueller, while well known in uranium detection, is actually more of use in X-radiation exposure for the detection of the presence of X-ray rather than detection of their amount.

Three other devices are in somewhat of use. The thermoluminescent dosimeter uses lithium floride or calcium fluoride to trap the electrons in a higher energy level. When heated, the trapped electrons return to the ground state and visible light it emitted. The amount of light emitted is measured to estimate the dose delivered by radiation. Another device of value in dosimetry is called the chemical dosimeter and makes use of the fact that certain crystals change colors upon exposure to X-radiation. Still another device is the calorimeter. The calorimeter, while capable of measuring X-radiation from the heat build up caused by the effect of the X-rays, is too complex and impractical a device to be in general use as an X-ray detector.

A radiation protection standard for radiation workers is necessary, obviously, to offer a guide to recommended maximum dosage that you, the technician, can go by. The standard is the maximum permissible dose (MPD), defined as the amount of radiation a normal human being may receive without any harmful effects to himself becoming evident within his lifetime. The maximum permissible dose equivalent (MPD) is based upon the accumulated dose over the entire lifetime for the individual.

No occupational dose is allowed persons under 18 years of age. The accumulated dose at any subsequent age, therefore, should not exceed (N-18) x 5; where 5 is the maximum dose rate per year, N is the age of the worker in years, and 18 is the age prior to which no occupational dose is allowed. Radiation protection guides further state that the maximum exposure for a three-month period should not exceed 3 rems. At age 18, an 18-year-old can receive 1.25 rems per quarter and up to as much as 3 rems in that year (see AR 40-14, para 6a(7)). For example, to calculate the MPD for age 20, then (N-18) x 5 = (20-18) x 5 = (2)5 = 10 rems. At age 31, then (N-18) x 5 = (31-18) x 5 = (13)5 = 65.

The radiation protection guides discussed here are subject to constant modification and revision. It is the professional responsibility of every radiologic technologist to remain alert to these changing guides.

Who is being protected when we follow all the precautions taught in radiologic protection? The patient, the technologist, and the general public. What type of radiation monitoring device provides for permanent record of exposure to radiation? The film badge. What relationship is there between roentgen, rads, and rems? They are all approximately equal to 1. 1 rad = 1 roentgen = 1 rem.

The last two hours we have studied types of radiation, definitions or units and sources of exposure. We have studied dosimetry, monitoring devices and you have learned to calculate the maximum permissible dose - MPD = (N-18) x 5.

In the Army environment you may at some time or another encounter more than one type of hazardous ionizing radiation. As an X-ray technician it will be your responsibility to monitor this radiation by carrying a film badge or similar device whenever you work near or in the vicinity of ionizing radiation. At some time in your career it may also be necessary for you to calculate the maximum permissible dose allowed for individuals who work by ionizing radiation. Hopefully, this lecture has helped you see the need of understanding the types of invisible hazardous radiation around you and how you, as a technician, can monitor it for your own safety.

CPT WILLIAM B. JOHNSON
ACADEMY OF HEALTH SCIENCES, US ARMY *LP 38-520-007
DIVISION OF MEDICINE AND SURGERY 047
X-RAY BRANCH

Radiation Protection: Specific Biologic Effects (2 hours)

COURSES PRESENTED TO: 313-91P10, X-Ray Specialist

PLACE: Classroom

REFERENCES:

TM 8-280, Chapter 3.
Barnett, M., and Eccleston, R. Radiation Protection During Medical X-Ray Examinations, Part 4: Biological Effects of X-Rays. HEW Publication No (FDA) 76-8048, March 1976.
Bushong, S. C. Radiologic Science for Technologists. St Louis: C. V. Mosby Company, 1975, Chapters 16 - 17.
Johns, H. E., and Cunningham, J. R. The Physics of Radiology. 3d ed. Springfield: Charles C. Thomas Company, 1971, Chapters 16 - 18.
Selman, Joseph. Fundamentals of X-Ray Protection. 5th ed. Springfield: Charles C. Thomas Company, 1972 Chapter 23.

STUDY ASSIGNMENT: Before class read TM 8-280, 3-13-15, and 3-24-30. After class study GR 38-520-007.

STUDENT UNIFORM AND EQUIPMENT: TM-820, GR 38-520-001A

TOOLS, EQUIPMENT, AND MATERIALS: TM 8-280, GR 38-520-001-1A

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Chalk, chalkboard, eraser, 35-mm, carousel projector; Annex A, S 38-520-007-1-50

TROOP REQUIREMENTS: None

TYPE OF INSTRUCTION: Lecture

THIRD AND FOURTH HOURS

I. INTRODUCTION (5 min)

A. Opening Statement: The X-ray technologist has a responsibility to understand the effects of radiation and protect all individuals from unnecessary X-ray exposures. There are many methods of radiation protection available for use. In today's society everyone is concerned with possible harmful biological effects from radiation exposure. Today, we will discuss the effects of X-rays in body tissues and methods to protect all individuals exposed to radiation.

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*This lesson plan supersedes LP 38-520-025, 050

B. Objectives

1. Given a situation, select the best method of radiation protection for each of the three categories of individuals who are exposed to radiation (i.e., the patient, the X-ray technologist, and the general public).

2. Given a list of cells, select the correct ranking of those cells in descending order of radiosensitivity.

3. State the concept of cumulative radiation.

4. State the difference between threshold and non-threshold doses.

5. List three factors which influence the amount of the effect produced by radiation.

6. List five effects of radiation on any type of cell.

7. Select four somatic effects of radiation.

8. Select the two components of radiation injury.

C. Class Procedure and Lesson Tie-in

None.

II. EXPLANATION (82 min)

QUESTION: Why is it important to understand the biological effects of X-rays?

ANSWER: Because of potential damage that can occur to the technologist, the patient, and the general public.

A. Concept #1: Radiation damage may be cumulative

1. Components of injury

a. Reparable

b. Irreparable

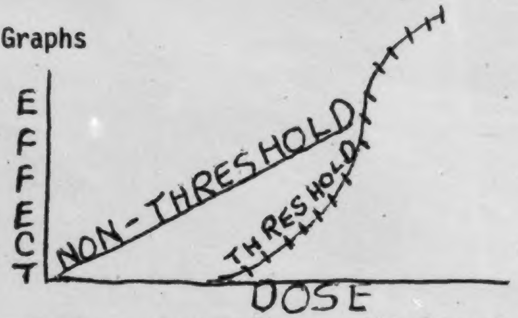
2. Irreparable injury accumulates

B. Concept #2: Any amount of radiation may produce some injury

1. Non-threshold dose: No safe dose

2. Threshold dose: Is a safe dose

3. Graphs



C. Three Factors that Influence the Amount of Effect Produced by Radiation

1. Dose rate

2. Area of body exposed

3. Variation in sensitivity of cells

D. Dose Rate

1. The faster the rate, the greater the effect

2. Time

3. Fractionation

E. Area of Body Exposed

1. Larger the area, the greater the effect

2. Shielding is very significant

   a. Therapy shield

   b. Collimation

F. Cell Sensitivity (Law of Bergonie and Tribondeau)

1. Young, rapidly dividing cells which have not yet specialized are most radiosensitive

2. Law of Bergonie and Tribondeau

   a. Reproductive capacity

   b. Degree of differentiation

3. Relative radiosensitivity of cell types from greatest to least

   a. Lymphocytes

b. Erythroblasts, Granulocytes

c. Myeloblasts

d. Epithelial cells

e. Endothelial cells

f. Connective tissue cells

g. Kidney tubule cells

h. Bone cells

i. Nerve cells

j. Brain cells

k. Muscle cells

QUESTION: What are three factors that influence the amount of the effect produced by radiation?

ANSWER: Dose rate, area of body exposed and variation in sensitivity of cells.

QUESTION: What is the Law of Bergonie and Tribondeau?

ANSWER: The radiosensitivity of a tissue is proportional to its reproductive capacity and inversely proportional to its degree of differentiation.

G. The Three Units - for Diagnostic X-Rays the Rad, Rem, and Roentgen Are Roughly Equivalent

NOTE: Use four transparencies to define chronic and acute exposure and genetic and somatic effects to radiation.

H. Definitions

1. Acute exposure - exposure to large dose of radiation over a period of time not to exceed 48 hours
2. Chronic exposure - exposure to radiation over a long duration of time
3. Long term effect - increased risk of certain diseases or harmful conditions
4. Genetic effects - changes in chromosomes of sperm or egg cells, exhibited in offspring
5. Somatic effects - changes in cells of individual exposed, not passed on to offspring

I. Difficulty In Measuring Long Term Effects

1. Must study large numbers of people
2. Long time periods

J. Effects of Radiation On Cells

1. Morphological
2. Mutation
3. Retardation of cell division
4. Total inhibition of cell division
5. Abnormal cell divisions

K. Genetic Effects - Caused by Alteration of a Sperm or Egg Cell

1. Fetal loss
2. Stillbirths
3. Neo-natal mortality
4. Congenital anomalies
5. Newborn size
6. Sex ratio

L. Mutations

1. Radiation increases mutation
2. Most are harmful
3. May increase susceptibility to disease

M. Somatic Effects

1. Increased incidences of cancer
2. Effects on developing embryo
3. Cataracts
4. Life span shortening

N. Increased Incidence of Cancer

1. Leukemia and other forms

2. Leukemia in Radiologists

   a. 1933 - 1942: 1.7 times greater among doctors than general public

   b. 1952 8 times greater among radiologists than the general public

O. Effect On Developing Embryo

1. Increase of risk of childhood cancer

2. Damage depends on amount and stage of pregnancy

   a. First two weeks - outright death

   b. Organogenesis stage (2d - 7th week) - gross anomolies, i.e., gross structural damage, CNS damage

3. Ways to avoid exposing embryo

   a. Doctor checks with patient

   b. Radiologist consults with referring doctor

   c. Technologist collimates and shields

P. Cataracts

1. Lens cells of eye die and remain

2. Opacities produced

3. Need high doses in humans

Q. Life Span Shortening

1. Non-specific - statistical phenomena

2. Irreparable damage

R. Radiation Protection

1. Type of radiation present in exposure room

   a. Primary

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- b. Leakage
- c. Secondary

2. Methods of protection
   - a. Patient
     - (1) Shielding
     - (2) Proper collimation
     - (3) Filtration
     - (4) Take the proper exposure the first time
     - (5) High kVp, low mAs technique
   - b. Members of the general public
     - (1) Lead apron
     - (2) Lead gloves
     - (3) Keep unnecessary persons out
     - (4) Keep exposure room doors closed
     - (5) Protective barriers
   - c. X-Ray Technologist
     - (1) Never hold the patient
     - (2) With portables use lead apron
     - (3) Keep distance
     - (4) Protective barriers
     - (5) Take the proper exposure the first time
     - (6) Proper collimation
     - (7) Filtration
     - (8) Grids

S. Questions from Students

III. SUMMARY (2 1/2 min)

A. Review of Main Points

1. Radiation protection: Specific biologic effects

2. Effects of ionizing radiation

3. Radiation protection (methods of protection)

B. Closing Statement: I would like to leave you with two thoughts. As an X-ray technician, you will be working nearly every day with radiation hazards, and it is extremely important for you to know what the possible effects of radiation damage are. When we know what will happen to the cell, we should then think about how to prevent such injury from happening in the beginning. So, as X-ray technicians, it is up to you to keep our patients, the general public, and ourselves safe from any undue X-ray hazard.

ANNEX A
INSTRUCTIONAL AIDS

Slides

38-520-007-1	Introduction #1
38-520-007-2	Introduction #2
38-520-007-3	Introduction #3
38-520-007-4	Introduction #4
38-520-007-5	Importance of understanding biological effects of X-rays
38-520-007-6	Concept #1
38-520-007-7	Graph #1
38-520-007-8	Graph #2
38-520-007-9	Concept #2
38-520-007-10	Threshold theory
38-520-007-11	Threshold graph
38-520-007-12	Threshold
38-520-007-13	Three factors
38-520-007-14	Dose Rate, Area, Sensitivity
38-520-007-15	Dose rate
38-520-007-16	Portion exposed
38-520-007-17	Shielding
38-520-007-18	Cell sensitivity
38-520-007-19	Bergonie and Tribondeau
38-520-007-20	Most sensitive cells
38-520-007-21	The three units
38-520-007-22	Definitions
38-520-007-23	Long term effects
38-520-007-24	Long term effects
38-520-007-25	Genetic effects
38-520-007-26	Long term effects #1
38-520-007-27	Long term effects #2
38-520-007-28	Long term effects #3
38-520-007-29	Long term effects #4
38-520-007-30	Effects of radiation on cells
38-520-007-31	Mutations
38-520-007-32	Fetal loss
38-520-007-33	Radiation increases mutation rate
38-520-007-34	Most mutations are harmful
38-520-007-35	May increase susceptibility
38-520-007-36	Somatic effects #1
38-520-007-37	Somatic effects #2
38-520-007-38	Increased incidence of cancer
38-520-007-39	Leukemia
38-520-007-40	Effect on developing embryo
38-520-007-41	Damage depends on:
38-520-007-42	Exposed in the first two weeks
38-520-007-43	Organogenesis
38-520-007-44	Unknowingly exposing the fetus
38-520-007-45	Doctor asks
38-520-007-46	Radiologist confers
38-520-007-47	Collimation
38-520-007-48	Cataracts
38-520-007-49	Life span shortening
38-520-007-50	Detection of life span shortening

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ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

Radiation Protection: Specific Biologic Effects

The X-ray technologist has a responsibility to understand the effects of radiation and protect all individuals from unnecessary X-ray exposures. There are many methods of radiation protection available for use. In today's society everyone is concerned with possible harmful biological effects from radiation exposure. Today, we will discuss the effects of X-rays in body tissues and methods to protect all individuals exposed to radiation.

The fact that ionizing radiation produces biological damage has been known for many years. It has only been within the last five years that the public has really been concerned with radiation damage, especially X-rays. Diagnostic X-rays contribute 66 - 90 percent of the total dose received by people yearly. As X-ray technologists, it is vital that you know the biological effects of radiation in order to protect yourself, the patient, and the general public. In addition, you will be the authority on radiation to the patient. Questions will be asked about adverse effects of radiation.

There are two general concepts about radiation that are important to understand. Concept #1 is: Radiation damage may be cumulative. There are two components to any radiation injury. Any radiation injury has a reparable and an irreparable component. From one acute exposure to radiation some damage will occur. Over time the injury will tend to repair itself, but will never reach the original condition. With multiple exposures, the irreparable component of the injury will continue to accumulate. Concept #2 states that any amount of radiation may produce some injury. This concept is a result of a controversy between two philosophies.

The non-threshold dose philosophy is that any amount of radiation can produce some effect. If we had sophisticated instruments, even low level effects could be detected. The threshold philosophy states that up to some point, a threshold, radiation injury is not caused. Beyond that point, damage may occur. Every effect would have a different threshold. There is supporting evidence for both philosophies. However, there is not enough evidence to say which philosophy is correct. In radiation protection we use the non-threshold philosophy since this places one on the safe side.

We will discuss three factors that influence the amount of the effect produced by radiation. The three factors are dose rate, area of the body exposed, and variation in the sensitivity of cells. The first of these factors is dose rate, that is, the amount of radiation delivered per unit of time. Generally, the faster the radiation is delivered, the greater the effect will be. Of course, the amount of time the radiation rate is delivered in will also influence the effect. Dividing the radiation dose into small fractions which are administered over a long period of time also tends to decrease the effect. The second factor is the area of the body exposed. In general, the larger the area of the body exposed, the greater the effect will be. This is one area where the X-ray technologist can really make an impact. Such actions as correct collimation and appropriate shielding can greatly reduce the area of the body that is exposed. This is also very effectively done in radiation therapy with the use of very large shields. The third factor, which has bearing on radiation damage, is the variation in cell sensitivity. Young, rapidly dividing cells which have not yet specialized are most radiosensitive. And conversely, those cells which do not reproduce rapidly and are highly specialized in function are most resistant to radiation. These two broad statements really summarize the law proposed by Bergonie and Tribondeau in 1906 which states: "The radiosensitivity of a tissue is proportional to its reproductive capacity and inversely proportional to its degree of differentiation." Based on this law, the various types of cells in the body can be ranked according to their sensitivity to radiation. Lymphocytes, erythroblasts, and myeloblasts, which are blood precursors, are the three most sensitive types of cells. Such cells as epithelial, endothelial, connective and kidney tubule cells are of intermediate sensitivity. Bone, nerve, brain, and muscle cells are least sensitive to radiation.

In order to intelligently discuss the specific effects of radiation, it is necessary to define some terminology. Two broad categories of exposure are acute and chronic exposure. Acute exposure is exposure to radiation over a period of time not to exceed 48 hours. It is usually a one-time exposure of radiation. Such exposures would usually result from accidents with radiation. Chronic exposure is exposure to radiation over a long period of time. One usually thinks of chronic exposure as occupational exposure. Also, the radiation dose is usually small. Examples of typical chronic exposures would be those exposures received by X-ray technologists and nuclear industry personnel. The reason for concern with chronic exposure is the possibility of damaging, long term effects.

The long term effect due to radiation is an increased risk of certain diseases or harmful conditions such as cancer or leukemia. Long term effects can be broken into two classes. The first class is genetic effects. A genetic effects results in a change in chromosomes of sperm or egg cells. This change is then exhibited in any offspring. The second class is somatic effects. Somatic effects are changes in the cells of the individual other than changes of the sperm or egg cell. The effect is oriented to that individual and is not passed on to any offspring. It is extremely difficult to measure long term effects. First, you must study large numbers of people. Second, long periods of time are needed for the study. The expenditures of time, personnel, and money make the study of long term effects difficult. Despite these problems, literature is full of long term studies on radiation effects. Many of these studies were done on animals. Some groups of people have been studied; such as, the Japanese survivors of World War II atomic blasts, radiologists,and individuals from accidents involving radiation.

There are five common effects of radiation on any type of cell. First, morphological changes can occur. If the cell shape is round, it would become elongated. Second, mutations could take place. These mutations might result in direct death of the cell. Third, a retardation of cell division could occur. Fourth, total inhibition of cell division is also possible. Fifth, abnormal cell division, which could result in explosive growth of cells, could occur.

Some genetic effects, which are caused by alteration of a sperm or egg cell, are: fetal loss, stillbirth, neo-natal mortality, congenital anomalies, newborn size, and sex ratio. Irradiation of the fetus during the first and second trimester can cause a condition called microcephally (small head). This condition can lead to mental retardation. Studies of the Japanese survivors of World War II atomic blasts showed that more females were born than males. Later, studies seem to indicate a shift to more females than males for all of Japan, so this data is suspect.

Mutations are caused by alteration in the genetic material of the cell. Radiation increases the mutation rate. Most mutations are harmful. If the mutation does not cause outright death, it may increase susceptibility to disease.

The somatic effects we will be concerned with are: increased incidence of cancer, effects on developing embryo, cataracts, and life span shortening.

Information linking X-rays with cancer is well known. Physicians working with X-rays before their harmful effects were understood are good examples. These indviduals received very large cumulative exposures, particularly to the hands. As a result, many of them developed cancers in the exposed areas. During the period 1933 - 1942, one study found a 1.7 times greater incidence of leukemia among doctors than the general public. In 1952 another study found the incidence of leukemia among radiologists to be eight times greater than the general public.

Long term somatic effects to the developing embryo can occur. Several studies have demonstrated an increased risk of cancer and leukemia in children whose mothers received diagnostic X-rays to the abdominal or pelvic areas during pregnancy. This does not mean that a child who has been irradiated before birth will necessarily develop cancer. As a matter of fact, the probability is still very low. Damage depends on the amount and the stage of pregnancy. If the exposure occurs during the first two weeks of pregnancy, outright death of the fetus can result. If it occurs in the first or second trimester, particularly between the second and seventh week - the organogenesis stage, gross anomalies such as structural damage and CNS damage can occur. If it is known that the fetus has been irradiated between 1 - 10 rads, then this is grounds for an abortion. Certainly anything over 10 rems to the fetus is definitely grounds for an abortion. Notice that these very important effects are produced early in pregnancy when the woman may have missed only one menstrual period and still may not know that she is pregnant. This poses a special problem to those of us who work with medical X-rays. How can we avoid unknowingly exposing a newly formed embryo? First, the physician who orders a pelvic, abdominal, or lower back X-ray examination on a woman should find out about the possibility of her being pregnant. If it appears that she may be pregnant, he should reconsider his need for X-rays. The patient should also take the initiative and tell her physician that she thinks that she might be pregnant. If the patient gets by the physician and the radiologist finds out that she is pregnant, he should then consult the physician and determine whether fewer views might be taken, shielding used, or the X-rays put off until after the child is born. If the X-rays are needed, with or without shielding, then it is up to the technologist to take special precautions. This includes collimation of the X-ray beam, use of shielding, setting the correct technique factors, and processing the film correctly to avoid retakes. Remember that every repeat film will expose the embryo or fetus to twice the original amount of radiation.

The third type of long term somatic effect from ionizing radiation is the induction of cataracts in the lens of the eye. When the lens is struck by radiation, the cells in the lens of the eye die. These cells remain and are not sloughed off; and if there are sufficient numbers of them, they can produce opacities which can interfere with vision. It is believed that large amounts of irradiation are needed to produce cataracts. Many studies are currently underway to study the effect of chronic exposure of X-rays in relation to cataract formation. Studies in mice show that as little as five rems can cause cataracts. During the next few years there are many studies underway which should yield more definitive results about the relationship between low level exposure and cataracts.

The fourth kind of somatic effect is life span shortening. Radiation is said to exert a non-specific life span shortening effect. By non-specific, we mean that it is a statistical phenomena. In order to observe any shortening of the life span, large numbers of experimental animals are irradiated at moderately high doses over long periods of time and on the average the irradiated ones died somewhat sooner. Life span shortening may be the result that the individual contacts cancer that he would not have, or it may be that he gets leukemia, or it may be just an increase in susceptability to other diseases. No life span shortening has been observed in medical X-ray personnel working at today's levels of permissible occupational exposure.

Several different types of radiation are present in the exposure room. There is primary radiation, leakage radiation, and secondary or scatter radiation. The primary beam, or useful beam as it is often called, is radiation which passes through the window, aperture, cone, or other beam limiting device of the source housing when the exposure switch or the timer is activated. Leakage radiation is all radiation coming from within the source of housing except the primary beam. Leakage radiation includes the portion of the radiation coming directly from the source and not absorbed by the source housing as well as the scattered radiation produced within the source housing. Scattered radiation is that radiation which during passage through matter has been deviated in direction. It may also have been modified by a decrease in energy. The scattered radiation is the result of Compton interactions. Secondary radiation is radiation that is completely absorbed during its passage through matter. The photoelectric effect is responsible for this kind of radiation. The low energy radiation given off as a result of this effect is immediately absorbed in the surrounding tissues. Many methods of protection from radiation are available. Some of the methods that are available are under the direct control of the X-ray technologists. There are three categories of individuals who are exposed to radiation: The patient, the X-ray technologist, and the general public. The best way to reduce exposure from radiation to the patient is to use proper collimation. Filtration of the primary beam is another way to reduce exposure to the patient. The filtration attenuates the low energy X-rays which cannot penetrate the film and only create more exposure to the patient. The use of high kV and low mAs techniques will reduce the patient exposure also. The use of good quality control on film development, as well as using correct technical factors, will alleviate the need for retakes and more exposure. Gonad shield should always be used when appropriate.

It should be pointed out that all of the methods that are available to protect the patient will also help protect the X-ray technologist. However, the primary means for protection of the X-ray technologist in a regular radiographic suite is the protective barrier. For fluoroscopy or when the X-ray technologist is using portable units on the wards, the primary means that the individual has for protection is the lead apron. For use of portables, distance is also an important factor. Any method that is employed to reduce scatter radiation will reduce the dose to the X-ray technologist. Such methods as, proper collimation, use of screens and grids, and proper design of the X-ray suite are all methods that can be employed. An X-ray technologist or anyone who is occupationally exposed to radiation should never hold a patient.

Many of the methods for protecting the general public are built in and not under the control of the X-ray technologist. By protecting the general public, we are speaking of individuals who may have an office next door or above or below the radiology suite or the patient who might be waiting outside the room. Such things as lead-lined walls and ceilings or floors are methods for protecting these individuals. However, there is another category for the general public. Many times, it is necessary for someone to hold the patient. Lead aprons and lead gloves should always be provided to individuals who are holding the patient. All unnecessary persons should be out of the radiology suite and the doors should be kept closed during X-ray examinations.

I would like to present you with two facts. First, human populations are being exposed to more and more X-ray procedures. Second, modern medical knowledge and techniques are saving more and more people with genetic defects. It is vital that you, as X-ray technologists, be aware of the biological effects of X-rays and the methods that you can use to protect yourself, the patient, and the general public from unwarranted exposures to radiation.

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ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

Radiation Protection: Gonad Shielding (1 hour)

COURSES PRESENTED TO: 313-91P10, X-Ray Specialist

PLACE: Classroom

REFERENCES:

TM 8-280, Chapter 3, para 29.
Selman, J. The Fundamentals of X-Ray Protection. 5th ed. Springfield: Thomas, 1969, Chapter 23, p. ~~425-27.~~ 475-477
Barnett M., and Eccleston, R. Radiation Protection During Medical X-Ray Examinations, Part 5: Gonad Shielding. HEW Publication No. (FDA) 76-8049, March 1976.

STUDY ASSIGNMENT: Read TM 8-280, Chapter 3, para 29 before class. After class, study GR 38-250-001-1C

STUDENT UNIFORM AND EQUIPMENT: TM 8-280

TOOLS, EQUIPMENT, AND MATERIALS: None

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Chalk, chalkboard, and eraser; 35-mm, carousel projector, Annex B, S 38-520-008-1-50

TROOP REQUIREMENTS: None

TYPE OF INSTRUCTION: Lecture

I. INTRODUCTION (2 1/2 min)

A. Opening Statement: One of the most current topics for debate in society today is radiation exposure received by patients undergoing diagnostic radiological procedures. Every week, in newspapers, you can find articles pertaining to public concern for any type of exposure to radiation. Too often, in the past, the radiologists and the technicians have scoffed at patient fears of radiation and have not done their jobs to protect the patient from unnecessary exposure. Today, we will discuss one method of protecting your patients from unnecessary radiation exposure.

B. Objectives

1. State the goal for gonad shielding.
2. State the four rules of thumb for using gonad shields.
3. List five X-ray procedures for which the use of gonad shielding would be appropriate.
4. List the three types of male gonad shields.

5. Briefly discuss the advantages and disadvantages of the three types of male gonad shields.

C. Class Procedure and Lesson Tie-in

Last period we discussed other methods to protect the patient from unwarranted radiation; such as, sufficient filtration, using high kVp's, and always collimating. Today, we will discuss another method: gonad shielding.

II. EXPLANATION (35 min)

QUESTION: Why is it important to shield the patient's gonads?

ANSWER: Radiation damage to sperm and egg cells can cause genetic mutations that would be passed on to future generations. Most genetic mutations are harmful.

A. Goal of Gonad Shielding

1. Not all people

2. Protect as many patients as we can

3. Never a substitute for collimation

B. Four Rules of Thumb for Gonad Shields

1. Shield patients who have likelihood of reproducing

   a. Exclude women past menopause

   b. Age limit up to each facility

   c. Three percent of US males 50-54 years old will father children during the remainder of their lives

2. Use gonad shields on all children regardless of age

   a. Genetic damage can occur before sexual maturity

   b. Damage is cumulative

   c. Genetic injury of sperm or egg cells passed on to next generation

3. Use shields whenever gonads are in direct beam or 5 cm from beam edge

   a. Scatter radiation from other exams - small

   b. Gonads irradiated during chest exam from direct beam would indicate poor collimation, not a need for gonad shielding

4. Use shielding only when it will not obscure needed diagnostic information

   a. Up to physician to decide

   b. Technologist then uses the shields

QUESTION: What are the four rules of thumb for using gonad shielding?

ANSWER: 1. Shield only when patient has a likelihood of reproducing, 2. It is always desirable to shield children, 3. Consider shielding when patient's reproductive organs are in the direct beam or within 5 cm of the edge of the beam, and 4. Use shielding only when it will not obscure needed diagnostic information.

C. Ovarian Shields for Females

1. Much more difficult
2. Shield obscures critical portions of pelvis due to anatomical position of ovaries
3. Interferes with visualization of parts of bladder, intestines, and lower spine
4. Anatomical position of ovaries varies
5. Sometimes possible to protect during selected procedures

D. X-Ray Projections for which Gonad Shielding is Appropriate

1. L-Spine
2. Myelogram
3. Pelvis
4. Hip
5. Abdomen
6. I.V.P.
7. U-GI
8. Ba E
9. Femur

E. Reasons for Not Using Shields in the Past

1. Inconvenient
2. Ineffective
3. Not acceptable

F. Three Types of Male Gonad Shields

1. Flat contact shield
2. Shaped contact shield with carrier
3. Shadow shield

QUESTION: What are the three types of male gonad shielding?

ANSWER: The flat contact shield, the shaped contact shield with carrier, and the shadow shield.

G. Advantages and Disadvantages of Each Type of Shield

1. Flat contact shield
    a. Advantages
        (1) Inexpensive and available
        (2) Easy to apply
    b. Disadvantages
        (1) Difficult to use in upright position
        (2) No protection during LA projection
        (3) Not appropriate for sterile procedures
        (4) Manipulation by technologist needed
2. Shaped contact shield
    a. Advantages
        (1) No manipulation
        (2) Can be used in upright position
        (3) Not necessary to reposition shield

(4) Protection during LA and oblique projections

b. Disadvantages

(1) Initial cost

(2) No protection for PA views

3. Shadow shield

a. Advantages

(1) Always ready for use

(2) No manipulation on patient

(3) Suited for sterile procedures

b. Disadvantages

(1) Cost

(2) Cannot be used with fixed collimation

(3) Misalignment

H. Use of Gonad Shields Reduces Dose by 90%

I. Quotes from Professional Bodies

1. American College of Radiology

2. International Commission on Radiation Protection

3. National Academy of Sciences

4. The National Council on Radiation Protection

QUESTION: What is the goal for using gonad shielding?

ANSWER: To protect as many patients as we can.

III. SUMMARY (2 1/2 min)

A. Review of Main Points

1. Goal of gonad shielding

2. Four rules of thumb

3. Appropriate procedures

I. INTRODUCTION

A. Opening Statement: Understanding the function of the X-ray tube is a must for the X-ray Specialist. Adjustment of the machine electrically to produce the desired radiographic results depends upon this knowledge. Prevention of tube damage is of equal importance and cannot be reduced without sufficient knowledge of the tube's function. The above average Specialist can be detected by the quality of the radiograph he turns out. Quality equals good positioning and correct manipulation of the electrical controls. If the Specialist is lax in either area he falls into a category lower than that of a good X-ray Specialist.

B. Objectives

1. State:

   a. the three requirements for X-ray production
   b. the names of tube parts, materials of construction of each, and its functions.
   c. the purpose of the Tube Rating Chart.

2. From Tube Rating and/or Tube Cooling Charts:

   a. determine whether a single exposure is safe.
   b. calculate the heat produced in a single exposure.
   c. calculate how many exposures may safely be made per minute.

NOTE: All formulas are to be memorized.

C. Class Procedure and Lesson Tie-in

None

II. EXPLANATION (165 min)

A. Film (45 min)

1. Introduction

a. "In Service of Science" (see Annex C)

b. Points to be observed

1) Construction of cathode

2) Construction of anode

3) Assembly steps involved

4) Construction of tube housing

2. Showing of film (25 min)

NOTE: See Annex A and follow printed outline. (Students using GR 38-520-001-1 have major underlined headings filled in and must fill in their notes as per Annex A.)

NOTE: Slides S 38-520-004-1 - S 38-520-004-23 are shown at appropriate points (see Annex B) as lesson is developed.

B. QUESTIONS FROM STUDENTS

III. SUMMARY (10 min)

A. Review of Main Points

1. Factors to produce X-rays
2. Stationary anode tube
3. Rotating anode tube
4. Tube rating chart

B. Closing Statement: By examing the X-ray tube and its components in the manner we have done over the past few hours, much of the mystery has been taken out of the production of X-rays. The instrument you will be operating in the near future is really very simply designed. Although it is a relatively uncomplicated appearing instrument it must never be treated as such. The possibility of overloading and burning out the tube is very real and for that reason, a rating chart is provided to enable you to check your exposure technique. The X-ray machine must always be handled with respect, for misuse may lead to machine malfunction and possibly patient or technician over exposure.

355

ANNEX A
INSTRUCTIONAL AIDS

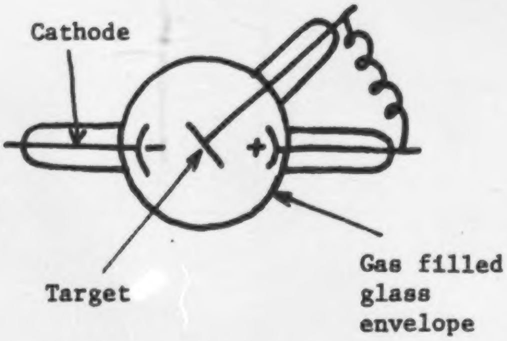
A. Conditions (requirements) for X-ray Production

1. Source of electrons
2. Means of acceleration electrons
3. Means of stopping electrons

B. Gaseous Type X-ray Tube

1. Construction

NOTE: Draw and label diagram
- a. Gas filled glass envelope
- b. Negatively charged cathode
- c. Target surface

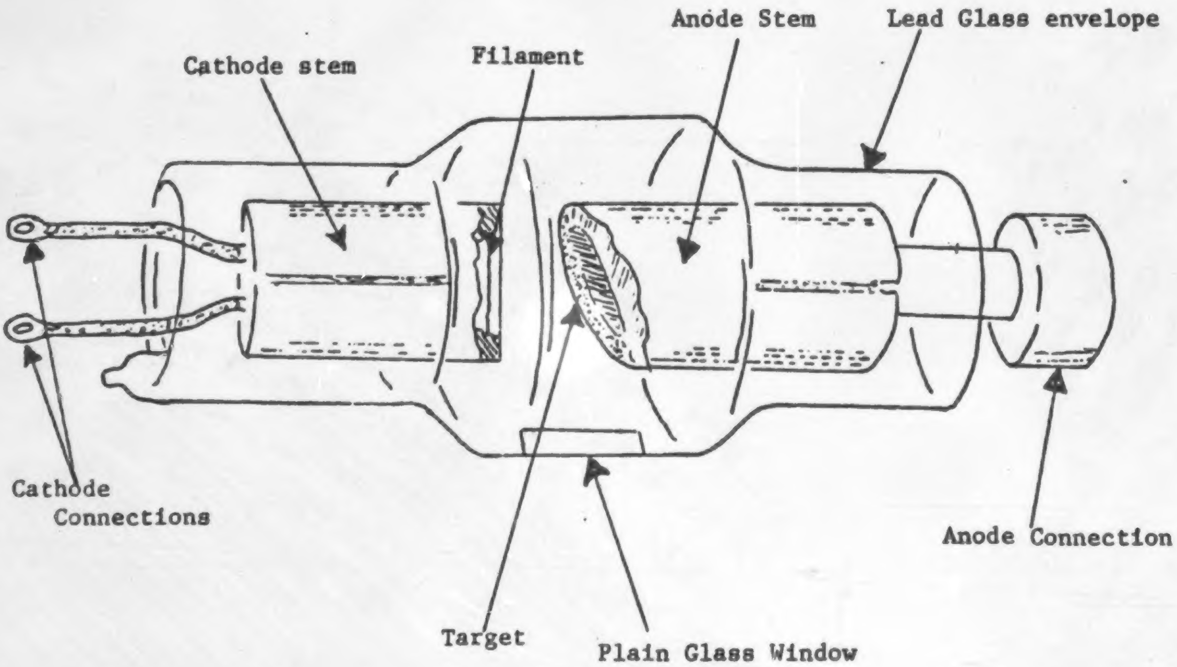

Cathode
(-
+)
Target
Gas filled glass envelope

2. Operation

- a. High potential between positive and negative electrodes
- b. Electrons from gas molecules accelerated from negative to positive electrodes
- c. Target stops portion of electrons
- d. X-rays produced as result of collision electrons with target.

C. Hot Filament X-ray Tube (Coolidge Tube)

1. General construction

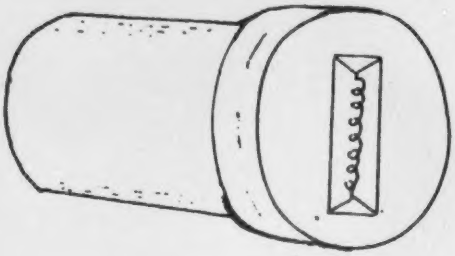

Anode Stem
Lead Glass envelope
Cathode stem
Filament
Cathode Connections
Anode Connection
Target
Plain Glass Window

2. Tube Break-Down

a. Cathode

1) Construction

NOTE: Draw and label diagram as below:


Cathode head
and Stem
(Nickel)
Focusing Cup
(Molybdenum)
Filament
(Tungsten)

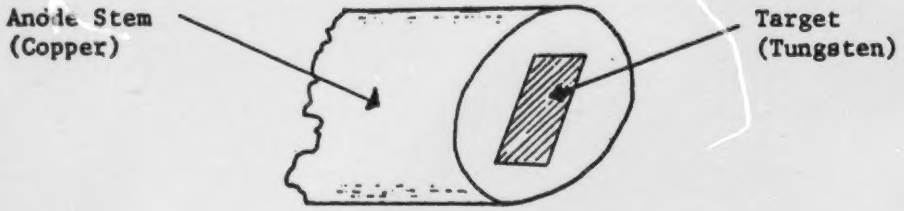
2) Purpose (Function)

a. Apply potential to cathode making it negatively charged.
b. Voltage to filament causes it to heat.
c. Electrons boiled off filament - thermionic emission.
d. Repel electrons from filament by negatively charged cathode.
e. Focusing cup aims electron beam.

b. Anode

1) Construction

NOTE: Label diagram as below


Anode Stem
(Copper)
Target
(Tungsten)

2) Purpose (Function)

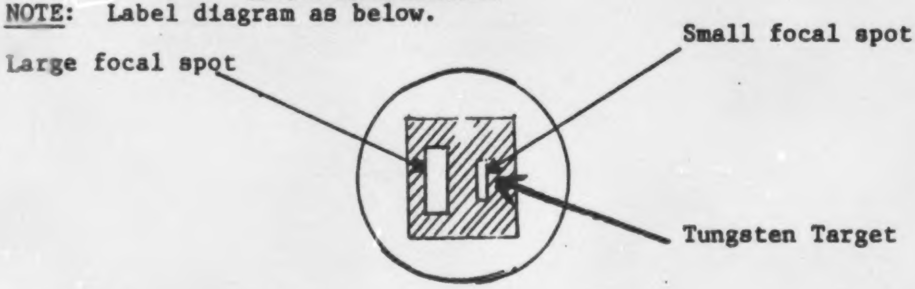
a. Apply potential to anode making it positively charged.
b. Absorbes electrons accelerated from filament.
c. X-rays produces

QUESTION: In the Coolidge tube which elements provide (1) source of electrons (2) means of acceleration of electrons (3) means of stopping electrons.

ANSWER: (1) The filament is the source of electrons (2) The difference in potential between cathode and anode accelerates the electrons (3) The tungsten target is where the electrons are stopped.

c. Focal Spot (Size)

NOTE: Label diagram as below.


Small focal spot
Large focal spot
Tungsten Target

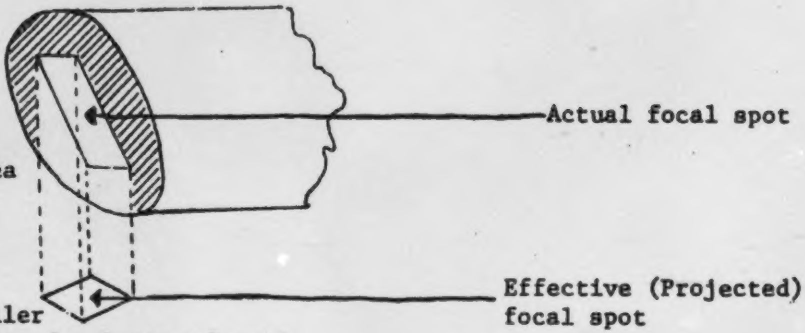
1) Small focal spot
   a. Better detail
   b. Shorter exposure time

2) Large Focal Spot
   a. Poorer detail
   b. Longer exposure time

359

b. **Line Focus Principle**

NOTE: Label diagram as below.



1) Anode face angled 17-21°

2) Actual focal spot provides large area for heat dissipation.

3) Effective focal spot projects smaller area through patient for better detail.

NOTE: The angled face allows large target area for head dissipation and longer exposure. However, it projects a smaller focal spot to patient for better detail.

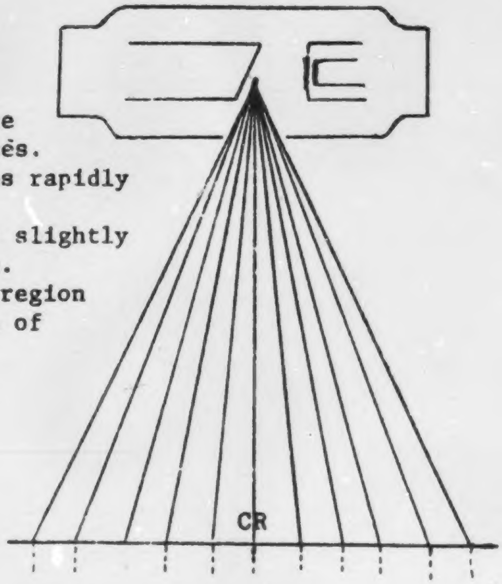
D. **Anode Heel Effect**

1. **Theory** - There is a variation in intensity of the X-ray beam due to the angle at which the radiation leaves the tube.

2. **Illustration**

NOTE: Label diagram as indicated.

a. Percentages indicate intensity differences.
b. Intensity diminishes rapidly toward anode side.
c. Intensity increases slightly toward cathode side.
d. Place thicker body region toward cathode side of tube.



370

3. Application of Anode Heel Effect

QUESTION: How can the anode heel effect be used?

ANSWER: If may be used to get uniform density on a radiograph when part thickness varies over the area of interest. Place the thicker region under the cathode side.

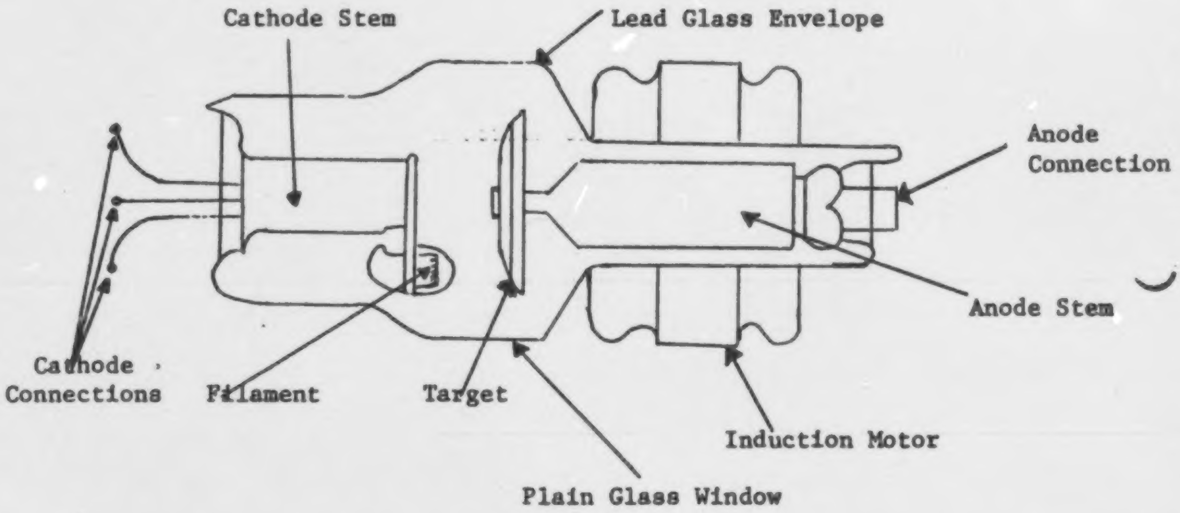
QUESTION: How does one determine the cathode side of the tube?

ANSWER: It may be labeled, or it may have a white button externally, or it will be cooler than anode side or you can trace the cables away from the transformer to cathode.

E. Rotating Anode Tube

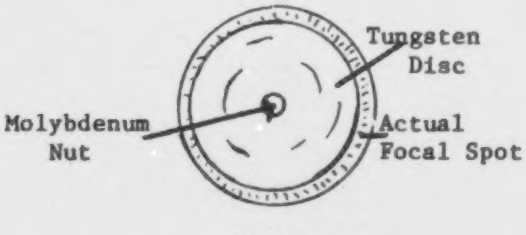
1. Construction

NOTE: Label diagram as below.

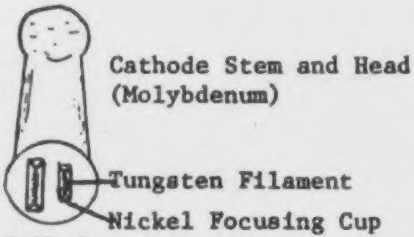

Cathode Stem
Lead Glass Envelope
Anode Connection
Anode Stem
Cathode Connections
Filament
Target
Induction Motor
Plain Glass Window

NOTE: Anode must attain a rotating speed between 3000 and 10,000 rpm before an exposure can be made.

NOTE: Label diagrams as below.


Tungsten Disc
Molybdenum Nut
Actual Focal Spot

Anode


Cathode Stem and Head (Molybdenum)
Tungsten Filament
Nickel Focusing Cup

Cathode

2. Advantages

   a. Four to six times greater capacity.

   b. Greater heat dissipation.

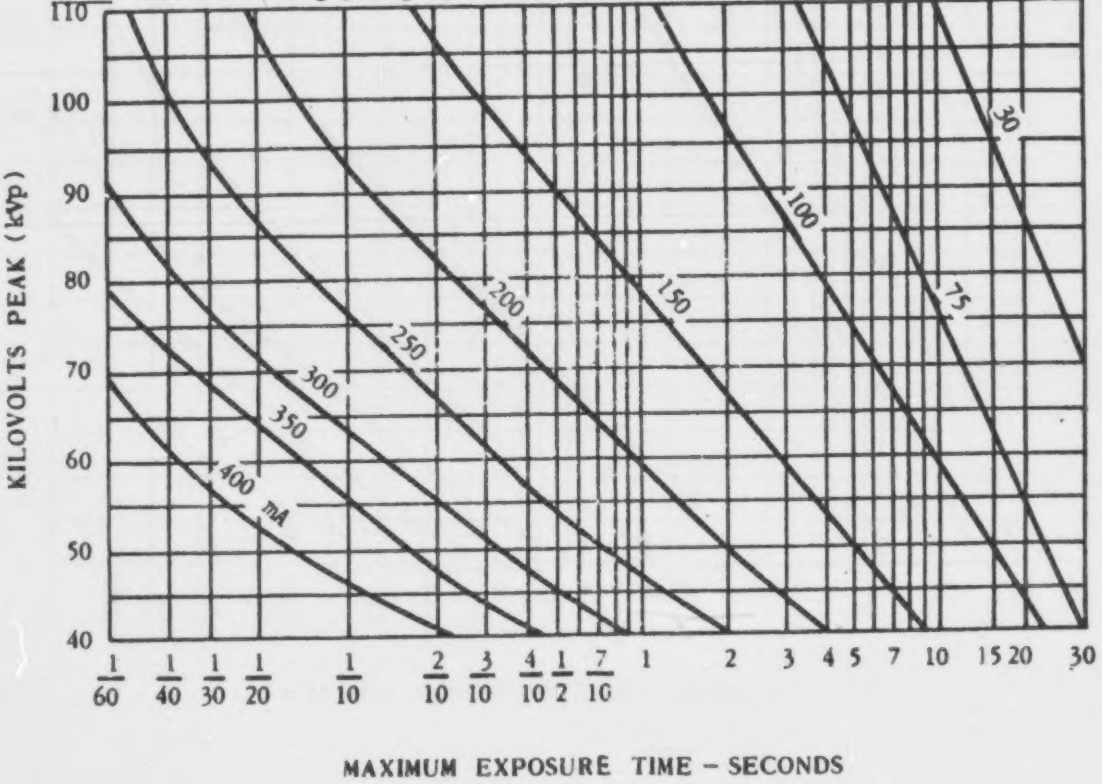
   c. Improved detail due to use of smaller focal spot.

f. Tube Rating Chart

   1. Purpose - To determine if one single exposure is safe for particular machine used.

   2. Application (Chart) LARGE FOCAL SPOT

NOTE: See following paragraph which is included on pg 43 of student's GR.



The tube rating chart is used to determine if a particular exposure is safe. Included on the tube rating chart are kVp, mA, and s. To determine the safety of any particular exposure, find the point of intersection of the kVp and s lines. If this point lies to the left and below the mA line to be used, the exposure is not likely to damage the tube. If, however, the point of intersection lies above and to the right of the mA line, tube destruction is almost certain. It should be noted that since a given mAs value may be arrived at by many combinations of mA and s, several possible different exposures may be used, some of which may be safe and some unsafe. In general, using higher mA values with shorter times will more likely produce unsafe exposures than lower mA with longer time to produce the same mAs. Note also that a tube rating chart is provided for each focal spot size. Naturally, the rating for a large focal spot is greater than that for a small focal spot on the same tube. Make certain you use the proper chart.

ANNEX B
INSTRUCTIONAL AIDS

Slide Series

S 38-520-004-1	Title, "X-ray Tubes and Rating Charts"
S 38-520-004-2	Illustrates the three factors needed for X-ray production.
S 38-520-004-3	Illustration of gaseous X-ray tube.
S 38-520-004-4	Illustration of hot filament tube.
S 38-520-004-5	Symbolic diagram fo X-ray tube.
S 38-520-004-6	Illustration of cathode.
S 38-520-004-7	Illustrates purpose of the filament.
S 38-520-004-8	Illustrates purpose of the focusing cup.
S 38-520-004-9	Illustrates the effect of kilovoltage
S 38-520-004-10	Illustrates electron movement from cathode to anode.
S 38-520-004-11	Illustration of line focus principle (Step No 1)
S 38-520-004-12	Illustration of line focus principle (Step No 2)
S 38-520-004-13	Illustrates effect of focal spot size.
S 38-520-004-14	X-ray production within the X-ray tube.
S 38-520-004-15	Factors used to control X-ray production.
S 38-520-004-16	Demonstration of X-ray production.
S 38-520-004-17	Illustrates efficiency of X-ray tube.
S 38-520-004-18	Illustration of rotating anode tube.
S 38-520-004-19	Illustration of advantages of the rotating anode tube.
S 38-520-004-20	Example of tube rating chart.
S 38-520-004-21	Illustration of heat unit formula.
S 38-520-004-22	Example of tube cooling chart.
S 38-520-004-23	Illustration of exposure/minute formula.

ANNEX C
INSTRUCTIONAL AIDS

Film Strip

25 minutes. "In the Service of Science," Machlett X-ray Corporation.

This film shows the construction and operation of the stationary anode X-ray tube and the rotating anode X-ray tube--manufacturing the X-ray tube; and the different types of X-ray and valve tubes.

NOTE: Points to be observed:

1. Construction of the cathode
2. Construction of the anode
3. Assembly steps involved
4. Construction of tube housing

365

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*IM 38-520-004
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X-Ray Tubes and Rating Charts

Understanding the function of the X-ray tube is a must for the X-ray Specialist. Adjustment of the machine electrically to produce the desired radiographic results depend upon this knowledge. Prevention of tube damage is of equal importance and cannot be reduced without sufficient knowledge of the tube's function. The above average Specialist can be detected by the quality of the radiograph he turns out. Quality equals good positioning and correct manipulation of the electrical controls. If the Specialist is lax in either area he falls into a category lower than that of a good X-ray Specialist.

There are three conditions that must exist to produce X-rays. We must have a source of electrons, a means of rapidly accelerating them to high speeds (up to one-third to one-half the speed of light), and a means of rapidly stopping them.

By accelerating the electrons to extremely high velocities, we impart a high kinetic energy to them. When the electrons are stopped, this kinetic energy is released as electromagnetic radiation and much of it is changed into X-rays.

The gas type tube consists of a negatively charged electrode called a cathode, a positively charged electrode called an anode and a target electrode interposed between the two sealed into a glass bulb from which most of the air has been removed. A small amount of residual air or gas remains in the tube. When a high negative charge is placed on the cathode and a high positive charge is placed on the anode, electrons are stripped from these gas molecules and stream across the tube. Thus, the gas itself becomes the source of electrons. It is the high voltage that forces the electrons to move across the tube and speed them up. At the target the electrons are rapidly stopped, their energies are released and X-rays are formed.

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*This instructor's manuscript supersedes IM 38-520-004, 083

In 1913 the General Electric Laboratories announced the invention of a new type of X-ray tube. This tube was named the Coolidge tube for its inventor. The Coolidge tube or hot filament tube again has a glass bulb to maintain a vacuum. The vacuum is, however, much better than those produced in gas type tubes since residual gases impair the operation of the hot filament tube. The glass is also a "lead glass," that is, it has lead salts dissolved in it to absorb the unwanted X-rays. A crown glass window allows the X-rays to exit the tube to form the useful beam of radiation.

The Cathode, however, is the feature which displays the greatest change from the gas type tube. The cathode includes a tungsten filament which, when it is heated to incandescence, "boils off" or liberates electrons which form a cloud about the filament. The filament is set into a slot in the cathode which is called the focusing cup.

The anode consists of a supporting stem of copper with a tungsten target imbedded into the face of the anode (the part facing the cathode). The target is angled about 20° from the vertical and is used to stop the electron stream.

The filament of the cathode then becomes the source of electrons. When the cathode becomes negatively charged, that is, when a voltage is applied to it, the electrons are repelled from the cathode and are attracted twoard the anode. As a result, the electrons stream across the tube at a high velocity.

The focusing cup is used to direct the stream of electrons in a narrow beam so they strike a small area on the anode. Were it not for the focusing cup the electrons would scatter in all directions from the filament.

The anode is kept positively charged during the operation of the tube. The high positive charge attracts the electrons from the filament and assists in making the "push" which forces the electrons at high speed across the tube.

The target is the portion of the anode which receives the electron bombardment. The small area on the target, which is actually being struck by the electrons and from which the X-rays are made, is called the actual focal spot. When the actual focal spot is viewed from the position of the center of the X-ray film, the actual focal spot appears to be square. Actually, it is rectangular, but the angle from which it is viewed causes it to appear to be square. That square appearing area is called the effective focal spot since, from the viewpoint of the film, the X-rays are effectively emitted from a square area. It must be said however, that the effective focal spot is not an actual part of the X-ray tube; it is only the actual focal spot as viewed from an angle.

The anode stem is made of copper to store and rapidly conduct heat from the target. Since better than 99 percent of the energy of the electrons crossing the tube is changed to heat (less than 1 percent is used in making usable X-rays), this heat must be rapidly removed lest the temperature of the target exceed the melting point and burn out the tube. Copper is a very good conductor of heat. It can also store large quantities of heat before reaching the melting point.

When the X-ray beam leaves the tube, the intensity of the radiation varies from cathode to anode. Thus, the cathode side intensity is approximately 105 percent of the intensity at the center. This effect is known as the heel effect. In radiography it is used to an advantage by placing the tube so that the X-rays on the cathode side pass through the thickest portion of the part under consideration. This allows a more consistent density on the radiograph.

The rotating anode tube is similar in principle to the stationary anode tube covered last hour. The main differentiating feature, however, is that the anode consists of a rotor of an induction motor set aside of the glass tube. On the rotor is a tungsten wheel which rotates rapidly.

The cathode is designed to focus the electron beam near the edge of the target wheel. At the wheel rotates, a new face of the wheel is constantly being exposed to the electron bombardment. The heat that is formed is spread uniformly around the edge of the target wheel and is dissipated much faster than when a stationary anode is used. This design does not in any way hamper the formation of X-rays, but it does facilitate the elimination of heat.

As X-ray tube using the rotating anode principle has from four to six time the X-ray producing capacity of a similar stationary anode tube. This type tube can also use smaller focal spots for longer exposures which results in better radiographic images, as we will see later on.

We will now see a film which shows how X-ray tubes are made (film: "In the Service of Science" by Machlett X-ray Corporation, 25 minutes).

The heat which is formed in the X-ray tube is dependent upon the kilovoltage, milliamperage, and time of exposure used. The higher the kilovoltage, the greater is the energy of electrons striking the target and the more heat is produced. The higher the mA, the more electrons strike the target per second and the more heat is produced. The longer the exposure time, the more electrons hit the target and the more heat is produced.

The maximum exposure that a tube can safely deliver is dependent on kVp, mA, s, and focal spot size. Larger focal spots can take more heat than small ones because of heat concentration.

The tube rating chart takes all these factors into consideration and tells whether or not a particular exposure will exceed the capacity of a given tube with a given focal spot.

In using the tube rating chart, select the kVp to be used from the vertical scale at the side. Select the time of exposure to be used along the lower horizontal scale. If the point of intersection of the kVp and s lines is below and to the left of the mA line to be used, the exposure is safe. If the point of intersection is above and to the right of the mA line, the exposure is unsafe and must not be used. The maximum exposure using a large focal spot is greater than with a samll focal spot.

The safe rating of the Tube Rating Chart should never be exceeded. If the technique chart includes exposures which exceed the maximum rating of the tube, the person who set up the chart is responsible for any damage that results from that technique. Damage which results when the Specialist does not follow the technique chart levels the responsibility of the Specialist.

By examining the X-ray tube and its components in the manner we have done over the past few hours, much of the mystery has been taken out of the production of X-rays. The instrument you will be operating in the near future is really very simply designed. Although it is a realatively uncomplicated appearing instrument it must never be treated as such. The possibility of overloading and burning out the tube is very real and for that reason, a rating chart is provided to enable you to check your exposure technique. The X-ray machine must always be handled with respect, for misuse may lead to machine malfunction and possibly patient or technician overexposure.

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X-RAY BRANCH

Mr. John Mayes
*LP 38-520-006
016

Inverse-Square Law (2 hrs)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES:

TM 8-280 pp 6-7, 6-8, Para 6-7 thru 6-9.
Selman, Joseph. The Fundamentals of X-Ray and Radium Physics. 5th ed. Springfield, Illinois. Charles C. Thomas, Publisher, 1972 pp 187, 307-311.

STUDY ASSIGNMENT: After class read TM 8-280, pp 6-7, 6-8, para 6-7 thru 6-9.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280, GR 38-520-001

TOOLS, EQUIPMENT, AND MATERIALS: N/A

PERSONNEL: One instructor (91P2H or 91P4H)

INSTRUCTIONAL AIDS: Chalk, chalkboard, eraser, Inverse-Square Law Training Aid (see Annex B).

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Lecture (2 hours)

I. INTRODUCTION (10 min)

A. Opening Statement: An understanding of the effect of changing the distance from the tube to the film (FFD) is essential for the proper operation of an x-ray machine. This relationship of distance to exposure is embodied in the inverse-square law. When performing portable x-rays, obstacles such as traction apparatus or casts will interfere with distance required, therefore, the inverse-square law must be applied to compensate for the change in distance.

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*This lesson plan supersedes LP 38-520-006, 062

B. Objectives

1. State how x-rays reaching the film are affected by:

    a. increasing the FFD
    b. decreasing the FFD.

2. Compute the new mAs required when changing a given exposure technique to a new FFD.

C. Class Procedure and Lesson Tie-in

None

II. EXPLANATION (70 min)

NOTE: Refer to Annex A for completed outline. (Students using GR 38-520-001-1, have major underlined headings filled in and must complete their notes as per Annex A.)

QUESTIONS FROM STUDENTS.

III. SUMMARY (5 min)

A. Review of Main Points

1. Definition

2. Formula

B. Closing Statement: In normal clinic operation, the need for using the inverse square is small. If, however, it is necessary to make portable radiographs (and it often is), the FFD values will quite often need a change; and a resulting mAs change must be made by using the formula or an approximation of it.

ANNEX A
INSTRUCTIONAL AIDS

A. Explanation

1. Definition of the Inverse-square Law: The intensity of radiation is inversely proportional to the square of the distance from the source.

   a. Intensity

NOTE: Explain quantity per unit of area per second.

   b. Inversely

NOTE: Explain difference between direct and inverse relationships.

   c. Square

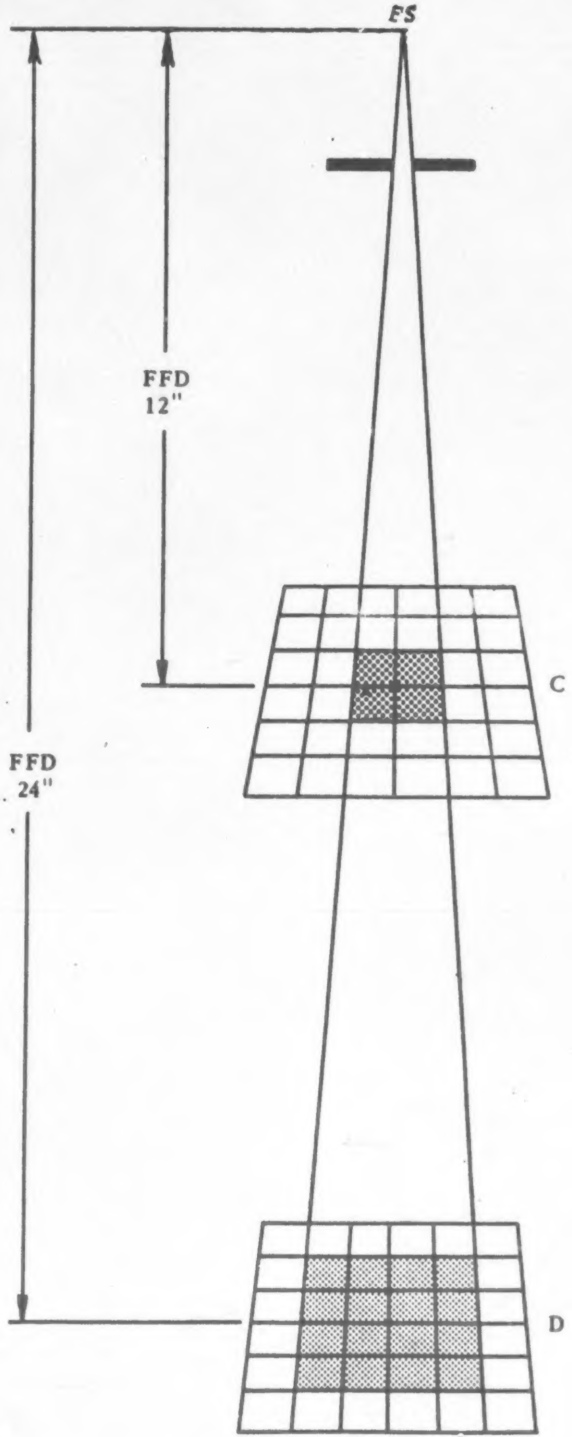
QUESTION: What do I mean when I write "8^2"?

ANSWER: 8 x 8 or 64.

B. Application to X-ray

NOTE: Demonstrate Inverse Square Law Training Aid using diagram following page when needed. See Annex B.

372


FS
FFD
12"
C
FFD
24"
D

Change in distance influences roentgenographic density.

C. Formula

1. $mAs_2 = mAs_1 \times \frac{FFD_2{}^2}{FFD_1{}^2}$

   a. Where:

      1. mAs_1 = original or chart mAs

      2. FFD_1 = original or chart FFD

      3. mAs_2 = new mAs (required because of new FFD)

      4. FFD_2 = new FFD (required by change in situation)

   b. Application

QUESTION: If I would normally use 5 mAs for a hand radiograph at 40 inches FFD, how would the film appear after changing my FFD to 60 inches and still use the 5 mAs for a hand?

ANSWER: Light, because of divergent rays and the inverse-square law.

D. Examples

NOTE: Work out sample problems on board for students.

a. mAs_1 = 30; FFD_1 = 36"; FFD_2 = 24"; mAs_2 = ?

b. mAs_1 = 10; FFD_1 = 72"; FFD_2 = 36"; mAs_2 = ?

c. mAs_1 = 7.5; FFD_1 = 40"; FFD_2 = 30"; mAs_2 = ?

NOTE: Give the remaining sample problems pp A-4, A-5, and let each student work them.

E. Problems

	mAs_1	mAs_2	FFD_1	FFD_2
1.	10	3.9	40	25
* 2.	5	2.8	40	30
3.	15	33.75	40	60
4.	40	27.7	36	30
5.	25	11.1	36	24
* 6.	30	37.04	36	40
7.	5	3.47	30	25
8.	15	12.15	30	27
9.	2½	3.6	30	36
* 10.	60	38.4	60	48
11.	10	4.44	60	40
12.	15	3.75	60	30
13.	25	6.25	72	36

	mAs_1	mAs_2	FFD_1	FFD_2
* 14.	40	27.7	72	60
15.	150	58.6	40	25
16.	75	42.2	40	30
17.	10	17.8	36	48
* 18.	20	9.6	36	25
19.	15	26.7	30	40
20.	5	3.2	30	24

F. Things to Note About Inverse Square Law

1. If the FFD is increased, the mAs must be increased (and vice versa).

NOTE: This is a direct relationship. Since the increased distance decreases radiation striking the film, an increase of the x-ray output (mAs) is needed to offset this effect

2. If the FFD is doubled, the mAs must be quadrupled (due to square).

376

3. If the FFD is halved, the mAs must be quartered (due to square).

4. If the FFD is changed from 48 inches to 36 inches or from 40 inches to 30 inches, the mAs is approximately halved (the other direction 2 x mAs).

QUESTION: What new FFD will cause the new mAs to be exactly ½ of the old mAs if my old FFD is 40"?

ANSWER: $\frac{1}{\frac{1}{2}} = \frac{40^2}{x^2}$

$x^2 = 800$

$x = 28.28$

387

ANNEX B
INSTRUCTIONAL AIDS

Inverse-Square Law Training Aid

I. Consists of:

A. Paper tubing cut to the shape of an anode and painted copper color.

B. Sixteen strings representing X-rays leaving focal spot of anode.

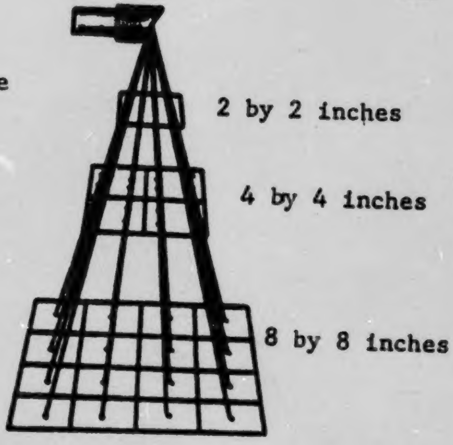
C. Three squares of cardboard at 10-, 20-, and 30-inch distances from anode.

1. Cardboard at 10 inches is 2 by 2 inches and has all 16 strings passing through with equal spacing.

2. Cardboard at 20 inches is 4 by 4 inches and has all 16 strings passing through with equal spacing (ruled into four 2- by 2-inch squares).

3. Cardboard at 30 inches is 8 by 8 inches and has all 16 strings passing with equal spacing (ruled into 16, 2- by 2-inch squares).

II. Demonstration:



A. At 10 inches, 16 rays strike a square (2 by 2 inches)

B. At 20 inches, four rays strike a square (2 by 2 inches)

C. At 40 inches, one ray strikes a square (2 by 2 inches)

D. Mathematical relationships

1. If D represents distance from anode to any film

2. If I represents intensity (number of strings)

3. Then $\frac{I_1}{I_2} = \frac{D_2^2}{D_1^2}$

4. Examples: $\frac{16}{4} = \frac{20^2}{10^2}$; $\frac{16}{1} = \frac{40^2}{10^2}$; $\frac{4}{1} = \frac{40^2}{20^2}$

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016

Inverse-Square Law

An understanding of the effect of changing the distance from the tube to the film (FFD) is essential for the proper operation of an x-ray machine. This relationship of distance to exposure is embodied in the inverse-square law. When performing portable x-rays, obstacles such as traction apparatus or casts will interfere with distance required; therefore, the inverse-square law must be applied to compensate for the change in distance.

The inverse-square law is familiar to all of you. At least it is familiar to you when connected with visible light. When reading by a lamp, you will find the light brighter close by than when the bulb is at a great distance. This is due to the inverse-square law.

The same principle holds with the x-ray tube. It is important that you understand this relationship in connection with the exposure of the x-ray film since changing the distance between the tube and the film will greatly affect the blackness of the film.

The inverse-square law states that: The intensity of the radiation is inversely proportional to the square of the distance from the source.

This will require some explanation and definitions. "Intensity" refers to the quantity of x-rays striking a given-sized area of the film per second of exposure. In other words, it makes a difference not only in how many rays strike the film, but also the area being struck by those rays and how long a time those rays are striking the film. If twice as many rays strike the same size area in the same length of time, twice the intensity is said to be used.

The term "inversely" refers to the way that two dependent variables depend upon each other; such that when one is increased the other will decrease. In the case of the x-rays, in the inverse-square law, the distance from the tube to the film is related to the intensity of radiation striking the film in an inverse relationship. This means that as the distance from the tube to the film is increased, there is a corresponding decrease in the intensity of the radiation striking the film.

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*This instructor's manuscript supersedes IM 38-520-006, 062

As opposed to the inverse relationship, a direct relationship may exist between two dependent factors. In the case of the direct relationship, if one of the dependent factors is increased, the other will also increase. If one is decreased, the other will also decrease. Although the direct relationship is not immediately related to the inverse square law, we will find that in practical application we will use a formula which is based on a direct relationship.

The term "square" refers to the mathematical process in which a number is multiplied by itself. For example:

$1^2 = 1 \times 1 = 1$ $3^2 = 3 \times 3 = 9$ $8^2 = 8 \times 8 = 64$

$2^2 = 2 \times 2 = 4$ $4^2 = 4 \times 4 = 16$

The inverse square law says then, that the intensity of the radiation striking the film will decrease by a factor of the distance squared as the distance is increased or vice versa.

Notice that at 10 inches from the tube, 16 rays (strings) strike the film (2 by 2 inches) while at 20 inches only four rays strike the same size area and at 40 inches only one ray strikes that area of the film.

The mathematical relationship can be shown by a formula. Using "D" as the distance from the anode of the tube to the film and "I" to represent the intensity or number of x-rays striking the unit area the following holds true:

$$\frac{I_1}{I_2} = \frac{D_2^2}{D_1^2}$$

For example, at 10 inches and 20 inches:

$$\frac{16}{4} = \frac{20^2}{10^2}$$

Or, at 10 inches and 40 inches:

$$\frac{16}{1} = \frac{40^2}{10^2}$$

Or, at 20 inches and 40 inches:

$$\frac{4}{1} = \frac{40^2}{20^2}$$

Practical Formula

The formula we discussed last period is the mathematical expression of the inverse-square law. It says for practical purposes that an increase of distance will cause a decrease in film density or blackness. This is not the way the relationship is used under practical conditions. We are not interested in changing the density or blackness of a film by changing the distance. We are interested in knowing how to keep the density or blackness of a film the same in spite of change in distance. In this instance, a new formula which is based on a direct relationship is most useful.

$$mAs_2 = mAs_1 \times \frac{FFD_2{}^2}{FFD_1{}^2}$$

In this formula, mAs represents the original mAs, the mAs that is listed on the exposure factor chart. FFD_1 is the original or chart FFD. (FFD is the focal-film distance or the distance from the focal spot of the tube to the film.) FFD_2 is the new FFD which is required by some change of conditions and mAs_2 is the required new mAs because of the change in FFD. Let us look at our training aid again. The idea is that the mAs determines the number of x-rays leaving the tube to get the same number of x-rays striking the film at a different distance, we must either increase or decrease the x-rays coming from the tube by a corresponding change in mAs. If we increase the FFD, we must increase the mAs. Note, however, that a doubling of the FFD requires more than a double of the mAs. It requires, in fact, four times as much due to the square of the FFD's.

Let us work some problems as examples. (See LP 38-520-006 for actual problems to be worked for the students.)

Now here are some problems for you to work. (Refer to the lesson plan for these problems. After sufficient time give the answers and show how the mistakes should be remedied.)

In working these problems, there are several short cuts which will enable you to work these problems much more easily. For example:

$$\frac{40^2}{30^2} = \frac{4^2}{3^2} = \frac{16}{9}$$

Notice that 10 can be divided into 40 and 30 to give 4 and 3. Note, however, that these numbers still must be squared.

Similarly: $\frac{36^2}{24^2} = \frac{3^2}{2^2} = \frac{9}{4}$ by dividing numerator and denominator by 12.

Even if no number will go evenly into both numerator and denominator, very often a close relationship will give a sufficiently accurate answer. For example:

$$\frac{48^2}{25^2} = \frac{50^2}{25^2} = \frac{2^2}{1^2} = \frac{4}{1}$$

Although approximations like this will be somewhat off the actual value, in most cases, it will be sufficiently accurate for practical application. The actual relationship for this problem is 3.7/1, but this is only 7½ percent from the approximation of 4/1. For practical purposes, if the approximate value is less than 20 percent off from the actual value, acceptable results will be obtained.

If the FFD is increased, the mAs must be increased, and if the FFD is decreased, the mAs must be decreased. Note that this is a direct relationship. Since the increased distance decreases radiation striking the film, an increase of the x-ray's output (mAs) is needed to offset this effect and produce the same density.

If the FFD is doubled, the mAs must be quadrupled. If the FFD is halved, the mAs must be quartered. This is due to the square of the FFD's.

As a "rule of thumb": If the FFD is changed from 48 inches to 36 inches or from 40 inches to 30 inches, the mAs is approximately halved to produce a similar density. If the changes are reversed, a doubling of the mAs is needed.

In normal clinical operation, the need for using the inverse-square law is small. If, however, it is necessary to make portable radiographs (and it often is), FFD values will quite often need to be changed and a resulting mAs change must be made by using the formula or an approximation of it.

NOTE: PAGE 382 HAS BEEN DELETED; HOWEVER ALL MATERIAL HAS BEEN INCLUDED.

383

Mr. Blair Bryant

*LP 38-520-007
015

ACADEMY OF HEALTH SCIENCES, US ARMY
MEDICINE AND SURGERY DIVISION
X-RAY BRANCH
FORT SAM HOUSTON, TEXAS 78234

Primary Factors of Exposure (2 hours)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES: TM 8-280
Medical Division, Eastman Kodak Company, Fundamentals of Radiography. 8th ed. Rochester, New York: Eastman Kodak Company, pp 15-18.

Selman, Joseph, The Fundamentals of X-Ray and Radium Physics. 5th ed. Springfield, Ill. Charles C. Thomas, Pub. 1972. pp 239-243.

STUDY ASSIGNMENT: After class study TM 8-280, pp 6-7 thru 6-16, para 6-7 thru 6-13, pp.6-26 thru 6-30 para 6-20.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280, GR 38-520-001-1 A

TOOLS, EQUIPMENT, AND MATERIALS: None

PERSONNEL: One instructor 91P2A/91P3#/91P4H

INSTRUCTIONAL AIDS: Film (This Is Radiography - 25 min. See Annex B) chalk, chalkboard, eraser, transparencies (See Annex C.)

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Lecture (2 hours)

I. INTRODUCTION (5 min)

A. Opening Statement: The process of producing a diagnostic radiograph does not simply involve positioning a patient and pressing the exposure button. As you are becoming increasingly aware, it is necessary for the technician to make a series of decisions which will determine the factors he sets on his machine prior to making an exposure.

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*This lesson plan supersedes LP 38-520-007, 010

Today you will be introduced to several of the factors which will influence techniques you use. These factors determine the quality and quantity of X-Rays reaching the film, and are called the primary factors.

B. Objectives

1. Define: Primary Factor

2. State:

a. How a change in any primary factor will affect:

1) electrons crossing the tube.
2) X-Rays produced (quality versus quantity).
3) X-Rays reaching the film after penetrating the part.

b. The function of any item on the control panel of the typical X-Ray machine.

C. Class Procedure and Lesson tie-in

None

II. EXPLANATION (70 min)

A. Film (25 min)

1. Introduction.

a. "This is Radiography" (see Annex B)

b. Points to be observed

1) Four factors which control radiation

2) Effect of those factors on radiograph

2. Definition of primary factors.

NOTE: See Annex A and follow printed outline (Students using GR 38-520-001-1 have major underlined headings filled in and must fill in their notes as per Annex A.)

NOTE: Transparencies T 38-520-007-1 thru T 38-520-007-5 may be shown at appropriate points as lesson is developed. (see Annex C)

385

NOTE: The questions listed in Annex B are to be used as appropriate for review following the film.

B. Student Questions

QUESTION: What is mA and how does it function?

ANSWER: mA indicates milliamperage. It is the controlling factor of the rate at which electrons are liberated from the filament. This factor affects the rate at which X-Rays are produced.

QUESTION: What effect would doubling the mA have on the X-Rays leaving the tube if all other factors remain constant?

ANSWER: The rate of production would be doubled. If all other factors remain constant, it would also double the number of X-Rays produced.

QUESTION: What effect would halving the s have on the X-Rays leaving the tube if all other factors remain constant?

ANSWER: Halving the s would reduce the quantity of X-Rays by one-half.

QUESTION: What is kVp and how does it function?

ANSWER: kVp indicates kilovoltage peak. This is the force applied to the cathode electrons. It is responsible for the speed at which these electrons move from cathode to anode.

QUESTION: What is the effect on the electrons crossing the tube when kVp is increased?

ANSWER: When kVp is increased the cathode electrons will move more rapidly toward the anode. Their speed is increased.

QUESTION: How does a decrease of kVp affect the X-Rays that are produced?

ANSWER: A decrease of kVp will decrease the energy of the X-Rays produced. This is to say the wavelengths will become longer.

QUESTION: What change occurs in the radiation leaving the tube when the FFD is doubled?

ANSWER: When FFD is doubled the radiation leaving the tube has a chance to diverge more than when using a short FFD. This has no effect on the quantity or quality of the radiation produced. It only effects the quantity of X-Rays striking a given area of the film.

386

QUESTION: How will the intensity of radiation reaching the film be affected by halving the FFD?

ANSWER: By reducing the FFD the X-Rays do not have a chance to diverge as much. This increases the quantity of radiation striking a given area of the film.

C. Questions From Students

III. SUMMARY (5 min)

A. Review of Main Points

1. kVp
2. mA
3. s
4. FFD

B. Closing Statement: As we have seen, the primary factors of exposure affect not only the way x-radiation is produced but how much of it strikes the film. Each time you as a technician set up your machine to make an exposure, you will have to choose the best set of primary factors which will give you the best diagnostic radiograph possible. Later in the course you will learn what affect each of these primary factors has on the radiograph itself.

396

ANNEX A
INSTRUCTIONAL AIDS

A. Definition of Primary Factors

1. Factors of exposure which are adjusted at the machine control panel.

2. Factors of exposure which control the kind (quality) and/or number (quantity) of x-rays reaching the film.

B. kVp - Kilovoltage Peak

1. Force needed to accelerate electrons between the cathode and anode at the speed of 1/3-1/2 speed of light.

QUESTION: Define primary factor.

ANSWER: Factors which control the quantity and quality of radiation reaching the film and which are machine adjustable.

2. Effect on Primary Beam

a. Speed of electrons
b. Wavelength of the primary beam
c. Penetration of the beam
d. Quality of the beam

C. mA - milliamperage

1. Number of electrons flowing from cathode to anode.

2. Effect on Primary Beam

a. Controls amount of radiation produced.
b. Quantity

D. s - time

1. Duration of exposure

2. Effect on Primary Beam

a. Controls amount of radiation produced
b. Quantity

ANNEX A
INSTRUCTIONAL AIDS

E. FFD - Focal Film Distance

1. Controls amount of radiation reaching the film.

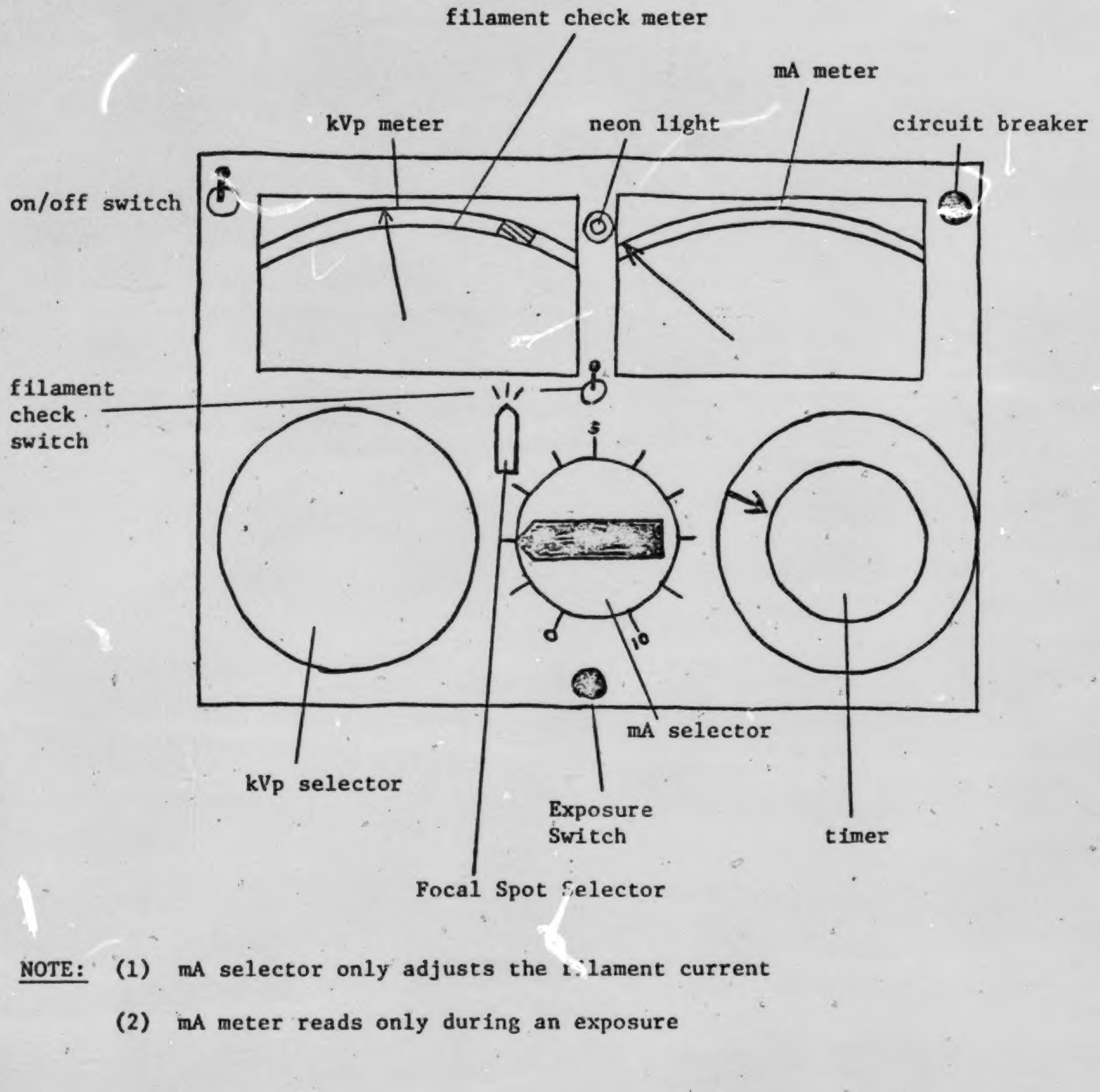
2. Effect

NOTE: As FFD increases, the amount of radiation reaching the film decreases and visa versa. An appropriate example might be that of watching how the beam of a flashlight spreads out as distance from a surface increases.

a. Quantity

F. Control Panel

NOTE: At this time bring the students around an x-ray machine control panel and show them the various control knobs. Following this, label the following diagram as indicated


filament check meter
mA meter
kVp meter
neon light
circuit breaker
on/off switch
filament check switch
5
0
10
mA selector
kVp selector
Exposure Switch
timer
Focal Spot Selector

NOTE: (1) mA selector only adjusts the filament current

(2) mA meter reads only during an exposure

G. Calibration of Equipment - List Steps

1. Close shutters, point machine head to ceiling
2. Set 70 kVp & 1 sec.
3. Start with small focal spot.
4. Turn mA dial to zero.
5. Make exposure and watch mA meter reading
6. Make another exposure and turn mA dial until 5 mA is obtained.
7. Note dial position
8. Press filament check switch and record meter reading.
9. Repeat steps #6 - 8 except increase mA each time to correspond with calibration chart.
10. Repeat same for large focal spot.

NOTE: Demonstrate usage of the following calibration chart.

CLAIBRATION CHART

Small Focal Spot: *

mA	5	10	15	20	25	30	40	50
Filament Check								
Control Dial								

Large Focal Spot: *

mA	5	10	15	20	25	30	40	50
Filament Check								
Control Dial								

QUESTION: When does the mA meter read?

ANSWER: Only during an exposure.

ANNEX B
INSTRUCTIONAL AIDS

Film Strip

25 minutes - "This is Radiography"

This animated film illustrates the primary factors and their relationship to effects produced on the film.

NOTE: Points to be observed.

1. Four factors which control radiation.
2. Effect of these factors on the radiograph.
3. Definition of Primary Factors.

ANNEX C
INSTRUCTIONAL AIDS

Transparancies

T 38-520-007-1	Definition and list of all primary factors
T 38-520-007-2	Shows effect of kVp
T 38-520-007-3	Shows effect of mA
T 38-520-007-4	Shows effect of s
T 38-520-007-5	Shows effect of FFD

393

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015

Primary and Secondary Factors of Exposure

Before discussing these primary factors, we will view a movie entitled, This is Radiography. This movie will give you an idea how these factors affect radiographic quality. After the movie is over we will discuss any questions pertaining to the film.

Basically, there are four primary factors of exposure. These factors will in some way affect either the kind or number of X-Rays leaving the tube. We can manipulate all primary factors from the X-Ray control panel or the tube stand.

The first factor we will discuss is kVp. These letters stand for kilovoltage peak. Speaking in electrical terms, voltage is a force applied to electrons making them move through a conductor which offers a certain amount of resistance. In Latin "Kilo" means x 1,000. One kilovolt then would be equal to 1,000 volts. In the X-ray tube we must apply a force to electrons giving them enough kinetic energy to flow between two electrodes. In order to accomplish this we must apply at least 30,000 volts or 30 kilovolts of electrical force to the electrons. The energy which these electrons display directly effects the amount of energy which the X-ray beam will have. The slower an electron moves between the cathode and anode, the less the energy of the photon produced. As the speed of the cathode electron increases, the energy of the photon also increases. So far we have been talking in terms of electron-photon relationships. Let us now state that a high energy photon is produced by a high speed electron and a low energy photon is produced from a slow moving electron.

X-rays have a higher energy value than that of light. We know that both travel through space in a wavelike motion. We also know that X-rays have a shorter wavelength than light. Because of the shorter wavelength and higher energy value, X-rays are more penetrating than light rays. To summarize we could say that the higher the energy of the X-ray, the more penetrating the X-ray will be. Remember that in the beginning electron speed governed the energy of the photon. We now can add to this and say that the force applied to the cathode electrons effects the penetrating power of the X-ray beam. This can be thought of in terms of quality. kVp affects the quality of the X-ray beam.

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*This instructor's manuscript supersedes IM 38-520-007, 083

Milliamperage determines the rate at which electrons are liberated from the filament. "Milli" means 1/1,000 so a milliamp would be equal to 1/1,000 of an amp. The electrical definition of amperage is the rate at which electrons move through a conductor. For every electron interaction in the target there will be a photon, or many photons produced. As the number of available electrons increases so does the number of photons. Milliamperage controls the quantity of X-rays/sec. If you double the mA you double the quantity of primary radiation.

The length of time which you allow the electrons to flow is controlled by the third primary factor. This factor is called "s". All X-ray machines control the time of exposure in increments of seconds. s is simply the abbreviation for the duration of the exposure. s also controls the quantity of the radiation produced. Whereas mA controls the rate, s controls the total quantity produced. By doubling the length of the exposure you would double the total amount of primary radiation produced.

So far we have been talking about kVp, mA, and s. All of these factors are controlled from the machine's control panel. The fourth factor, FFD, is controlled from the tube stand. FFD indicates the distance between the focal spot of the X-ray tube and the X-ray film. FFD means focus-film distance. By changing the FFD you in no way affect either the kind or number of X-rays leaving the tube. X-rays have the ability to diverge. This is one of their properties. By moving the film further away from the source, you allow the X-ray beam to diverge and as a result less radiation will strike a given area of the film. Remember that FFD affects the quantity of X-rays striking a given area of the film, but not leaving the X-ray tube.

Next week prior to your beginning actual work with the x-ray machines you must calibrate the machine. The function of calibration is to allow you to correlate a particular mA dial setting with the desired mA selection.

The steps of calibration are listed below:

1. Close collimater shutters and point tube head to ceiling.

2. Set 70 kVp and 1 sec.

3. Start with small focal spot.

4. Turn mA dial to zero.

5. Make exposure and watch mA meter reading.

6. Make another exposure and turn mA dial until 10 mA is read on meter.

395

7. Note dial position.

8. Press filament check switch and record meter reading and dial reading.

9. Repeat steps 6-8 except increase mA each time to correspond with calibration chart.

10. Repeat same for large focal spot. Calibration must only be done on an non-fixed mA station machinery.

As we have seen, the primary factors of exposure affect not only the way x-radiation is produced but how much of it strikes the film. Each time you as a technician set up your machine to make an exposure, you will have to choose the best set of primary factors which will give you the best diagnostic radiograph possible. Later in the course you will learn what affect each of these primary factors has on the radiograph itself.

396

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*LP 38-520-009
055

Accessory Devices (3 hours)

COURSES PRESENTED TO: 313-91P10, X-Ray Specialist

PLACE: Classroom

REFERENCES:

TM 8-280,
Selman, Joseph. The Fundamentals of X-Ray and Radium Physics. 5th ed. Springfield, Illinois: Charles C. Thomas, Publisher, 1972, pp 329-357.

STUDY ASSIGNMENT: Read TM 8-280, p 3-15, para 3-29c, p6-21 thru 6-26, para 6-18 thru 6-19.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280, GR 38-520-001-1A

TOOLS, EQUIPMENT, AND MATERIALS: None

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Flare cones, extension cylinder, stationary grid, bucky, pieces of old grid, lead diaphragms, sandbags, sandwich boards, calipers, angliner, filters, chalk, chalkboard, transparencies, and overhead projector

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Lecture

FIRST THROUGH THIRD HOURS

I. INTRODUCTION (5 min)

A. Opening Statement: When working in an X-Ray Clinic the Specialist should be mainly concerned with patient comfort and film quality. Many times it is necessary for a patient to hold a difficult position. It is the specialists' job to make this patient as comfortable as possible and still obtain a diagnostic radiograph. Any device which is used to help a patient hold a difficult position, to improve film quality, or to offer extra protection from radiation is termed an accessory device.

This lesson plan supersedes LP 38-520-009, 010

B. Objectives

State:

1. The purpose of filtration, types of filtration and minimum filtration required.

2. The definitions of:

   a. grid ratio
   b. grid focus
   c. grid radius

4. The relationship between grid efficiency and grid ratio.

5. The proper grid usage to avoid grid lines and grid cut-off.

6. The relative efficiency of collimation as compared to grids.

II. EXPLANATION (120 min)

NOTE: Refer to Annex A for transparencies which will be shown as appropriate to instruction.

NOTE: Refer to Annex B for print outline. (Students using GR 38-520-001-1, 084 have major headings filled in and must fill in their notes as per Annex B).

III. SUMMARY (10 min)

A. Review of Main Points

1. Most common devices

2. Grids

3. Bucky

B. Closing Statement: We have discussed the basic devices which are used with the X-Ray machine. Of all these devices, the grid is one of the most useful in improving radiographic quality.

ANNEX A
INSTRUCTIONAL AIDS

Transparencies

T 38-520-0090-1	Shows the grid ratio.
T 38-520-0090-2	Shows production of secondary radiation within the part under consideration (with usage of a flare cone).
T 38-520-0090-3	Shows reduction of secondary radiation with a cylinder cone as compared to a flare cone.
T 38-520-0090-4	Shows the effect of a diaphragm on reduction of secondary radiation production.
T 38-520-0090-5	Shows how the grid prevents secondary radiation from striking the film.
T 38-520-0090-6	Shows the effect of having too short of an FFD for the grid radius.
T 38-520-0090-7	Shows the effect of having too long of an FFD for the grid radius.
T 38-520-0090-8	Shows the effect of angling across the lead strips of a grid.
T 38-520-0090-9	Shows the effect of placing the grid upside down.

ANNEX B
INSTRUCTIONAL AIDS

ACESSORY DEVICES

A. Definition

Any device used with an x-ray machine for the purpose of:

1. Providing ease of patient positioning
2. Improving film quality
3. Protecting the patient

B. Commonly Used Devices

1. Sandbag

a. Construction

Canvas bag of sand

b. Purpose

Immobilize the patient - reduce motion

2. Sandwich Board

a. Construction

Lead sheet sandwiched between layers of pressed board, plywood or plastic.

b. Purpose

Cover a portion of the film while exposing another portion.

3. Masks

A sandwich board device with 2 circular holes used while exposing small regions within the part. Normally used for bilateral views in skull region.

4. Angligner

A protractor device used for assisting in achieving proper angular relationships between the tube, part and film.

5. Angle Board

A wooden or sponge device which is designed to hold the film and/or part at a specific angle during exposure.

6. Calipers

Used for measuring part thickness.

7. Filters

a. Construction

Thin sheet of aluminum. Normally callibrated in millimeters of thickness. Most common: .25, .5, 1.0, 1.5 mm.

b. Purpose

To remove long wavelength - low penetrating x-rays from the beam. Protects patient from x-rays too weak to form a useful image. Does NOT appreciably affect secondary radiation.

c. Types

(1) Inherent (glass, oil, plastic portal in tube) Built into tube head - unavoidable. Equivalent to 0.5 mm Al at minimum.

(2) Added - Aluminum sheets added to inherent filtration to give total filtration.

Total filtration - sum of inherent and added filtration - minimum permissible: 2.5 mm AL equivalent filtration for kV̄p levels above 70, 1.5 mm Al equivalent for kV̄p from 50-70, 0.5 mm Al equivalent (only inherent) below 50 kV̄p.

8. CR Stick

Assists in alignment of CR to part and for determination of FFD for angled parts.

9. Others
   "Lead" aprons and gloves
   Compression band
   Red goggles for fluoroscopy - darkroom dark accommodation.

10. Cones

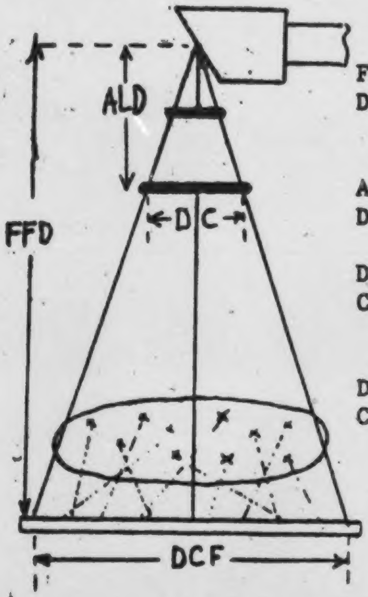
   a. Purpose
      To absorb unwanted outer portion of the X-ray beam. Has no appreciable effect on the number of primary radiation or penetration of x-rays reaching film. Does affect secondary radiation fog, density, patient exposure.

   b. Types

      (1) Flare Cone
          Purpose: To just cover a given size of film.

Unknown is always DCF for a flare cone.

$\underline{DCF} \times ALD = DC \times FFD$



FFD
Focal Film Distance

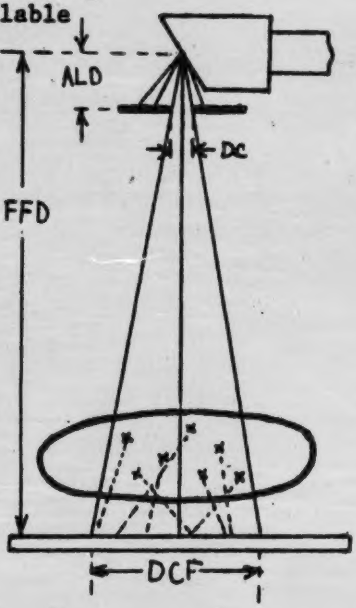
ALD =
Anode - Lip Distance

DC =
Diameter of Cone

DCF =
Diameter of Conefield

(2) Diaphragm

Used only when other coning devices are not available



Hole is cut in lead sheet (DC) of the diameter needed to produce a given size of conefield.

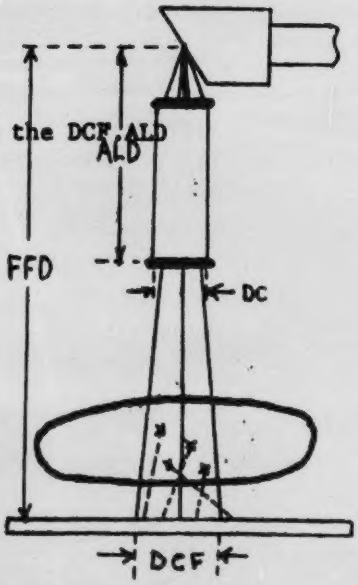
DC is always the unknown with a diaphragm.

DCF X ALD = DC X FFD

(3) Cylinder

Purpose: To produce a small conefield of exposure in the center of the film. Normally the cylinder can be lengthened or extended to change the size of the conefield to the desired size.

The ALD is the unknown value using the DCF ALD formula



DCF X ALD = DC X FFD

411

(4) Collimator

Adjustable lead shutters at the tube.
Can adjust to any size conefield.
Some produce rectangular and some circular cone fields.
Usually a light shows the center of the X-ray beam, the area of film being exposed or both.

11. Grids

a. Purpose

To absorb the secondary radiation leaving the patient's body and prevent it from reaching the film.

b. Construction

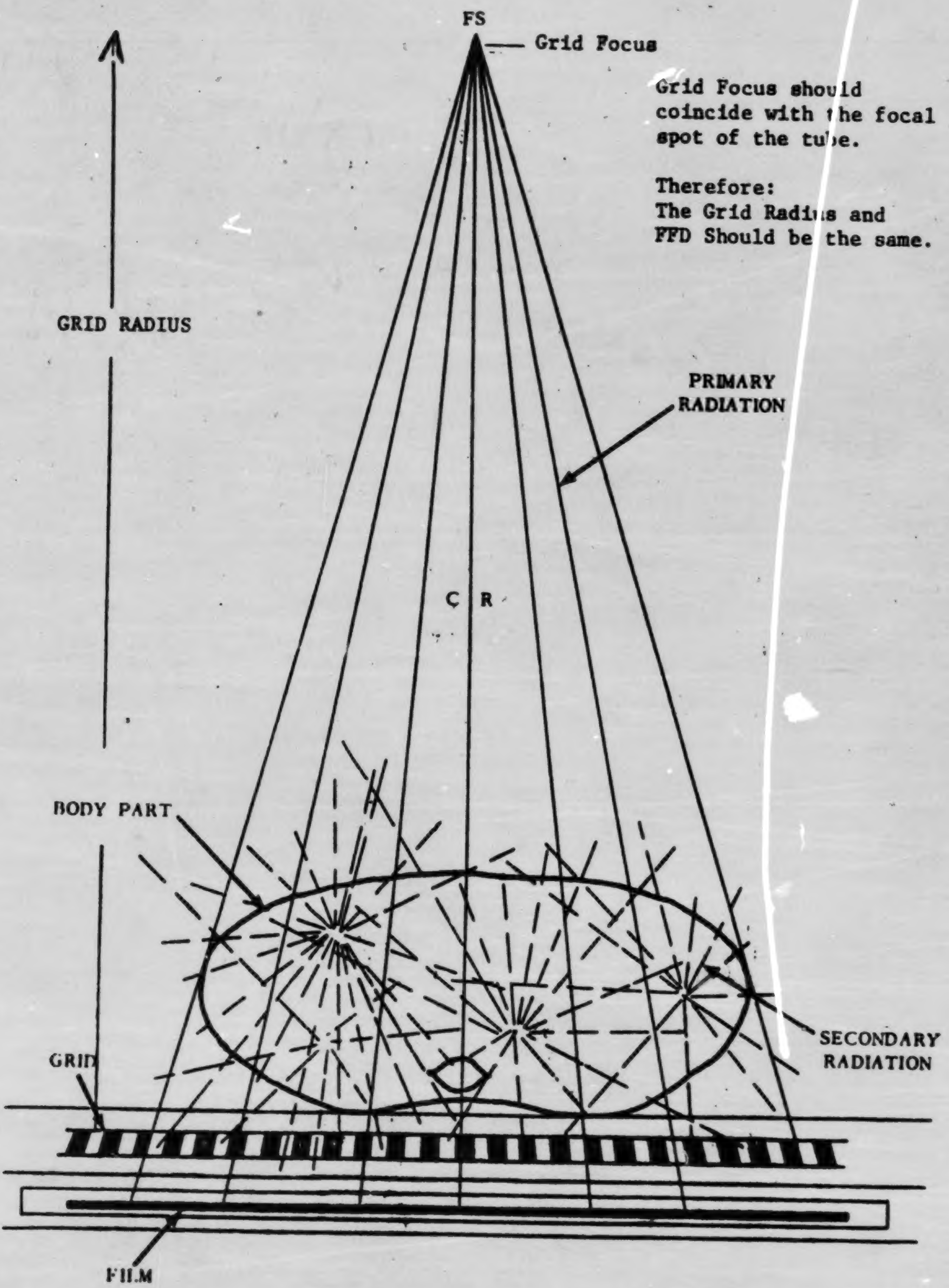
Alternate strips of lead and radiolucent material.

c. Terminology

(1) Grid Ratio

Height of lead strips divided by Distance between them.

$$GR = \frac{H}{D}$$


FS
Grid Focus
GRID RADIUS
PRIMARY RADIATION
C R
BODY PART
SECONDARY RADIATION
GRID
FILM

Grid Focus should coincide with the focal spot of the tube.

Therefore:
The Grid Radius and FFD Should be the same.

(2) Grid Focus

Point at which all lead strips would meet if extended.

The Focal Spot should coincide with the Grid focus in use.

(3) Grid Radius

Distance between Grid Focus and center of the grid - should be same as FFD.
Rule of Thumb for 8:1 grid FFD can be off - 25%
For 16:1 grid 1" is critical in FFD

d. Stationary Grids

ALWAYS PRODUCE GRID LINES.

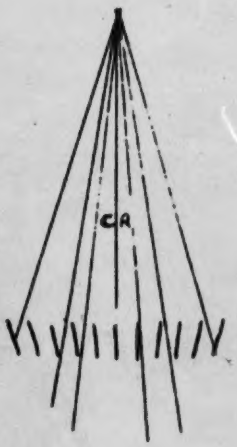
(1) Application
Use on top of film and beneath patient.
Used only when Bucky is not usable.

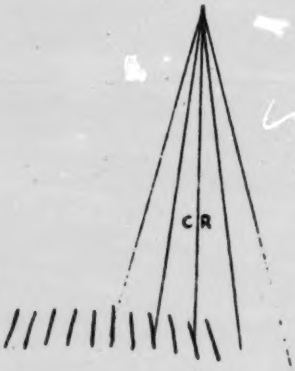
(2) Types

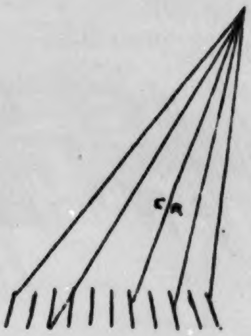
Stationary Grid - non moving, added to cassette
Grid Cassette - nonmoving, built into cassette

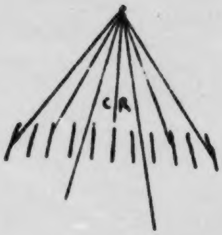
e. Potter - Bucky Diaphragm

Moving grid blurs out grid lines.
Film remains stationary in Bucky tray below grid.
Bucky must move evenly during entire exposure
or grid lines are produced.









f. Grid cut-off

(1) Definition

Partial or complete absorption of radiation due to grid absorption. Film appears light or completely clear, usually at one edge or on opposite sides of the film.

(2) Causes

a. Inverted Grid
Both sides have cut-off with image running full length of the film.

b. Miscentered CR
Entire film light but especially on one side.

c. Misangled CR (angled against grid strips)
Usually almost complete absorption.

d. Wrong FFD
Film light at edges but usually a proper density in the center.

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DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

*IM 38-520-009
055

Accessory Devices

When working in an X-ray Clinic the Specialist should be mainly concerned with patient comfort and film quality. Many times it is necessary for a patient to hold a difficult position. It is the specialists' job to make this patient as comfortable as possible and still obtain a diagnostic radiograph. Any device which is used to help a patient hold a difficult position, to improve film quality, or to offer extra protection from radiation, is termed an accessory device.

The commonly used devices will be discussed below:

Sandbags are, as the name implies, bags of sand. They are used primarily to hold or support the patient while in a difficult position. Sandbags are used primarily to prevent motion of the part during the exposure, although they may be used to support the film or even the tubestand under certain adverse conditions. It should be cautioned that, ordinarily, it is not desirable that the sandbag be allowed to come between the X-ray tube and film.

Sandwich boards are used to "lead off" the film. When it is desired to make two or more exposures on the same film, the portion which is unused for a given exposure must be protected from the X-ray beam. Sheets of lead can be used for this, but the sandwich construction using lead sandwiched between two pieces of plywood prevents the soft lead from bending and breaking. When it is necessary to use two or more sandwich boards side by side it is also necessary to lead off the crack between them.

Masks are sheets of lead (or may be of the sandwich board construction) which have one or two holes cut into them. They are usually used to radiograph small portions of interest within the skull. They also are used to show bilateral views of a given part.

The Angliner is a convenient device to facilitate angulation of the part. Although the word Angliner is a trade name, the basic idea is that of the protractor with an indicator which moves across the scale and is lined up with the part to be examined. A homemade protractor of cardboard or preferably of clear plastic with a string through the center point will suffice and improve the ease of angulation of tough-to-handle parts.

Calipers are used to measure the thickness of the part to be radiographed. Usually they are calibrated in centimeter but may also include inch measurements.

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*This Instructor's manuscript supersedes IM 38-520-009, 010

408

Filters are the only commonly used devices whose only function is to protect the patient. Unless used in excess of 3 to 4 mm. of aluminum, filtration does not affect the radiographic image. The filters remove long wavelength rays which would otherwise have no effect on the film, since they are almost wholly absorbed by the part. A reduction of the radiation to the patient of approximately one-third occurs when going from 2 mm. to 3 mm. added filtration.

The natural or inherent filtration consists of the glass of the X-ray tube (about 1 mm.), the layer of oil just outside the tube (about 1.5 mm.), and the plastic portal of the tube (about 1 mm.) absorb X-rays to about the same degree as would 1/2 mm. (.5) of aluminum.

Thin sheets of aluminum which are interposed between the tube and the patient are called added filters. It is recommended by the National Bureau of Standards (HB 60) that a total filtration of 2.5 mm. of Al or more be used.

Cones are, as the name implies, conically-shaped devices. The point of the cone is cut off leaving a flare-shaped device with an opening of different sizes at each end. The cone is used primarily for the purpose of absorbing the unwanted part of the X-ray beam to reduce the amount of secondary radiation that is formed. It does, however, also reduce the volume of tissue exposed to the patient, thus reducing his absorbed dose.

The cone is placed beneath the X-ray tube and absorbs the outer margins of the beam. It must be noted that the cone does not focus or bend the beam of radiation, but only absorbs those rays which would go in directions beyond the film.

Cones may be of various sizes--both diameter and length can be changed.

In determining what size area is covered on the film using a given cone, the following formula is used: DCF x ALD = DC x FFD. Where FFD is focal-film distance, ALD is the distance from the anode to the lip of the cone, DCF is the diameter of the conefield, and DC is the diameter of the bottom or mouth of the cone.

The cylinder is cylindrically shaped and can often be changed in length, in which case it is called an extension cylinder. Basically, the cylinder is used to reduce the amount of fog on the film due to secondary radiation just as does the cone. The cylinder, however, since it covers a smaller area, will reduce the amount of fog even more than will the cone. The cylinder is used to place a small spot of radiation in the center of a film while the cone is designed to cover the whole film. In using the formula DCF x ALD = DC x FFD with an extension cylinder, the unknown factor is ALD to produce a desired DCF.

417

409

The diaphragm is essentially the same type of device as the cone and cylinder--that is, it is used to absorb the unwanted part of the X-ray beam. It differs mainly in design. The diaphragm consists of a sheet of lead with a hole of suitable size and shape to make exactly the desired conefield on the film. The formula DCF x ALD = DC x FFD can be used to determine the exact size of hole (DC) which should be cut in the lead to give the desired DCF.

A variable apertures device called a collimator combines the best features of the cone and diaphragm. It also minimizes penumbra. It is provided with two sets of adjustable diaphragms placed one above the other, that can be adjusted to any desired rectangular conefield. Most collimators are equipped with an illuminated beam centering device of some sort.

Grids are used to prevent secondary radiation that is formed from getting to the film. The grid consists of alternate strips of radiolucent materials and lead. These lead strips are lined up so the primary rays from the X-ray tube will be able to pass between the strips while the secondary rays, since they go at all angles, will run into the sides of the lead strips and be absorbed. In the modern grid there are from 50 to 60 lead strips per inch with 55 being a good average.

The modern grid strips are directed to a point above the center of the grid which is called the grid focus. These types of grids are called focused grids. The distance from the grid focus to the center of the grid is called the grid radius. For an 8:1 grid (to be explained later) the grid focus should not be exceeded by more than 25 percent in either direction.

The grid ratio of a grid determines the effectiveness in absorbing secondary radiation. Grid ratio is defined as the ratio of the height of the lead strips to the distance between them. In general, the higher the grid ratio, the more efficient it is in absorbing secondary radiation.

The stationary grid is designed to be used in situations in which it is impossible to use the moving grid. It is a stationary grid and is focused. Since it is a focused grid, the side of the grid which faces the tube is marked and grid cutoff will result if the opposite side is placed next to the tube. Any angulation must be done in the direction parallel to the grid strips. Note that grid lines will always be produced when using a stationary grid.

The effect of FFD, angulation, using the grid placed upside down, and using a grid when it is not centered to the midline are demonstrated by using the mock-up grid, a light source and a piece of translucent plastic.

This motion blurs out the grid image but does not effect the image of the part. There are two methods of providing for this motion.

The older manual, cock-type Bucky utilizes a spring which pulls the grid across the film during the exposure. Prior to exposure, this type of grid must be "cocked" to stretch the spring and enable the grid to move during the exposure. With this type of Bucky, it is also necessary to start the grid just prior to exposure and the grid must be uniformaly moving throughout the exposure time. Exposure must also terminate before the grid stops moving. On the other hand, if the grid time is greatly more than the exposure time, the film may show grid lines because the grid is over one portion of the film more often than another. Thus, it is important to closely adjust the grid to provide motion extending throughout the exposure time. The manual cock-type Bucky should not be used for exposures of less than 3/4 second since the difference in grid time and exposure time necessarily becomes greater, and grid lines are likely to appear at shorter exposures.

The reciprocating grid is moved by a motor-cam combination that moves the grid first one direction and then the other. The reciprocating grid is usually automatically started at the beginning of the exposure as long as a "Bucky" switch is in the "on" position on the control panel of the machine.

The effect of a movable grid is demonstrated by the use of a reciprocating bucky. Show the direction of travel in relation to the part and the film.

We have discussed the major devices which are used with the X-ray machine. Of all these devices, the grid is probably the most useful in improving radiographic quality.

ACADEMY OF HEALTH SCIENCES *LP 38-520-013
MEDICINE AND SURGERY DIVISION 018
X-RAY BRANCH

Secondary Factors of Exposure and Film Discussion (7 hours)

COURSES PRESENTED TO: 313-91P10, X-Ray Specialist

PLACE: Classroom

REFERENCES:

TM 8-280
Medical Division, Eastman Kodak Company. Fundamentals of Radiography. 8th ed. Rochester, New York: Eastman Kodak Company, pp 25 - 29.
Selman, Joseph. The Fundamentals of X-Ray and Radium Physics. 4th ed. Springfield, Illinois: Charles C. Thomas Publisher, 1969, pp 277 - 330.

STUDY ASSIGNMENT: After class, study TM 8-280, Chapter 6, para 6-4 through 6-30.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280, GR 38-520-001-1B.

TOOLS, EQUIPMENT, AND MATERIALS: None

PERSONNEL: One instructor, 91P2H/91P3H/91P4H

INSTRUCTIONAL AIDS: Demonstration radiographic film file on secondary factors of exposure; view box, chalk, chalkboard, eraser, transparencies (see Annex A).

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Lecture (7 hours)

I. INTRODUCTION (5 min)

A. Opening Statement: In our discussion of the primary factors of exposure you have learned that these are factors which are both adjustable on the instrument control panel and which determine both the quantity and quality of the X-ray beam. Carrying this one step further, it is logical to assume that these primary factors will affect the final radiograph in some manner. When you look at the radiograph, you must assess its acceptability and you will be making your judgment on the quality of the film. Those factors which give the film its descriptive characteristics are termed secondary factors and these are density, contrast, detail, and distortion of exposure.

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*This lesson plan supersedes LP 38-520-013, 087.

For the next seven hours, we will be examining the relationships between the secondary factors and the primary factors of exposure and viewing radiographs which lend supportive evidence to these relationships.

B. Objectives

1. List the four secondary factors.

2. List the two auxiliary factors (OFD and focal spot size) which affect secondary factors.

3. State which primary factor(s) affect(s) each secondary factor and fog and the relationships (direct or inverse) between them.

4. State how each secondary factor and fog is affected by any given primary factor.

C. Class Procedure and Lesson Tie-in: None

II. EXPLANATION (305 min)

NOTE: Refer to Annex B for completed outline. (Students using GR 38-520-001-1B have major underlined headings filled in and must complete their notes as per Annex B). Transparencies will be used as appropriate (see Annex A).

Questions from Students

III. SUMMARY (5 min)

A. Review of Major Topics

1. Definitions of secondary factors

2. Relationship of primary factors to secondary factors

B. Closing Statement: The relationships between the primary and secondary factors are extremely important. Your knowledge of the interrelations will determine, to a large extent, the success or failure of each radiographic exposure. Furthermore, by being able to recognize the secondary factors, you will be able to evaluate the quality of your work and determine its acceptability.

ANNEX A
INSTRUCTIONAL AIDS

TRANSPARENCIES

T 38-520-013-1	Definitions of primary and secondary factors.
T 38-520-013-2	Primary factor review.
T 38-520-013-3	Auxiliary factors of exposure.
T 38-520-013-4	Density.
T 38-520-013-5	Auxiliary factors affecting density.
T 38-520-013-6	Contrast.
T 38-520-013-7	Primary factors affecting contrast.
T 38-520-013-8	Auxiliary factors affecting contrast.
T 38-520-013-9	Detail.
T 38-520-013-10	Primary factors affecting detail.
T 38-520-013-11	Auxiliary factors affecting detail.
T 38-520-013-12	Distortion.
T 38-520-013-13	True distortion.
T 38-520-013-14	Fog.
T 38-520-013-15	Auxiliary factors affecting fog.

414

ANNEX B
INSTRUCTIONAL AIDS

FIRST THROUGH THIRD HOURS

A. Definitions

1. Primary Factors of Exposure - Review

   a. Factors which control the kind of number of X-rays in the primary beam and which are machine controlled.

   b. Factors:

      (1) kVp - quality

      (2) mA - quantity

      (3) s - quantity

      (4) FFD - quantity

2. Secondary Factors of Exposure

   a. Definition: Factors which give the film its descriptive characteristics (film quality).

   b. Secondary Factors:

      (1) Density

      (2) Contrast

      (3) Detail

      (4) Distortion

3. Auxiliary Factors of Exposure

   a. Definition: Additional factors which have nothing to do with X-ray production, but do affect the film quality.

   b. Factors:

      (1) Object Film Distance

      (2) Focal Spot Size

      (3) Processing of Film

      (4) Grids

423

(5) Type of Film Holder

B. Density

NOTE: Show films from packet F 38-520-013-1-5. (See Annex C)

1. Definition: Blackness on a radiograph (quantity of black metallic silver on a film).

2. Primary Factors Affecting Density

QUESTION: Which primary factors do you think affect density and in what way?

ANSWER: kVp, mA, s - directly; FFD - inversely.

a. kVp

QUESTION: Why does kVp affect density?

ANSWER: The penetration is changed and the number of rays penetrating the part and reaching the films is changed.

QUESTION: How much of a change in each of the primary factors is necessary to produce a noticeable effect on the film?

ANSWER:
4% - kVp (Here a small change will affect the film; other factors must be changed by a larger %.)
20% - mA
20% - s
10% - FFD

QUESTION: How much of a change in each of the primary factors is necessary to double density?

ANSWER:
+12-15% kVp
+100% mA
+100% s
-33% FFD

NOTE: Therefore, to double the density using kVp, one must ADD between 12-15% of the original kVp. To double the density using mA or s, one must simply double the mA or s (to halve density, halve the mA or s). To double the density using FFD, one must SUBTRACT 33% (or a third) of the original FFD.

b. mAs

QUESTION: Why does mAs affect density?

ANSWER: mAs determines the number of X-rays produced, and this determines how many pass through the patient and reach the film.

(1) Small increments

416

QUESTION: How do small percentage changes of mAs affect the film?

ANSWER: To no visible degree.

(2) Large increments

QUESTION: How large a change in mAs is required to produce a noticeable density change?

ANSWER: About 20 percent.

(3) Conclusions

c. FFD

QUESTION: How does FFD affect density?

ANSWER: An increase of FFD will decrease density.

(1) Large increments (2 x FFD and 1/2 x FFD)

QUESTION: If the FFD is doubled, what happens to density?

ANSWER: It is reduced to 1/4.

(2) Small increments

(3) FFD^2

QUESTION: Mathematically the FFD is related to density inversely to the ________________________?

ANSWER: Distance squared.

3. Auxiliary Factors Affecting Density

a. Developing

(1) Time

(2) Temperature

(3) Agitation

(4) Chemical Activity

b. Patient Size

c. Type of Film

425

d. Type of Film Holder

e. Grids

f. Cones

g. Filters

C. Contrast

NOTE: Show films from packet F-38-520-013-6 (see Annex C).

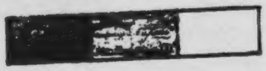
1. Definition: The difference between two or more tonal values on a radiograph.

NOTE: Scale of contrast: The number of shades of grey (tonal values) on the film.

2. Types

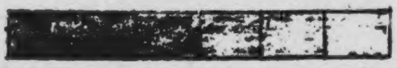
a. High contrast - short scale

NOTE: Discuss the following diagram and note the distinguishing characteristics.



b. Low contrast - long scale

NOTE: Discuss the following diagram and note the distinguishing characteristics.



3. Primary Factors Affecting Contrast

QUESTION: Which primary factors affect contrast and why?

ANSWER: kVp only because it affects the penetrating power of the beam.

QUESTION: What relationship exists between kVp and contrast?

ANSWER: Inverse - as kVp increases, contrast decreases. In other words, the scale of contrast increases as kVp increases.

QUESTION: Why do mAs and FFD not affect contrast?

ANSWER: mAs and FFD affect only the number of X-rays reaching the patient and in no way affect their penetrating power.

4. Auxiliary Factors Affecting Contrast

a. Type of film

b. Type of film holder

c. Developing processes

d. Grids

e. Cones

f. Filters

g. Patient

FOURTH THROUGH SIXTH HOURS

D. Detail

NOTE: Show films from packet F-38-520-013-7 (see Annex C).

1. Definition

QUESTION: What is meant by radiographic detail?

ANSWER: The sharpness of the X-ray image.

2. Primary Factors Affecting Detail

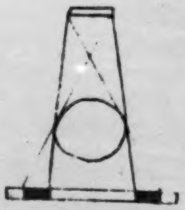
QUESTION: Which primary factors affect detail?

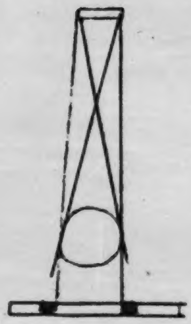
ANSWER: s and FFD.

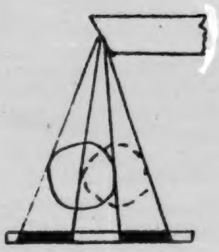
QUESTION: Why do kVp and mA have no affect on detail?

ANSWER: These factors do not affect the path X-rays take to reach the film.

NOTE: Using the following illustrations, explain the effects of FFD and s on the radiograph.







QUESTION: Does time always affect detail?

ANSWER: No, it only affects detail when patient movement is a problem.

QUESTION: Under ideal conditions, should a long or short FFD be used?

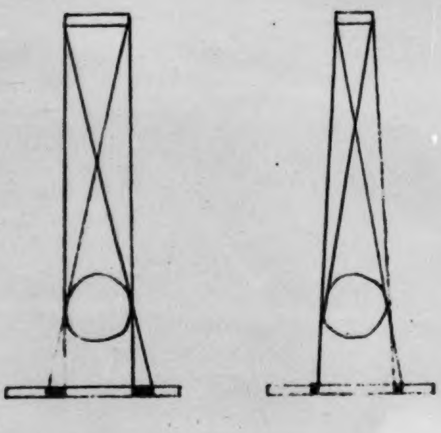
ANSWER: Long.

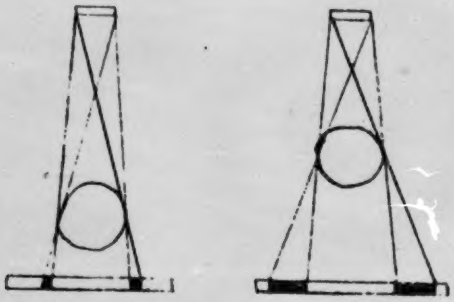
3. Auxiliary Factors Affecting Detail

QUESTION: What auxiliary factors affect detail?

ANSWER: Focal spot size, object film distance, type of film holder, type of intensifying screen, screen film contact.

NOTE: Use the following illustrations to explain the effects of focal spot size and object film distance.





QUESTION: When should the small focal spot be used?

ANSWER: It should always be used unless the exposure may damage the tube - then the large focal spot should be used.

E. Distortion

NOTE: Show films from packet F-38-520-013-8&9. (See Annex C)

1. Definition: Changing the size and/or shape of an object

2. Types

a. Magnified

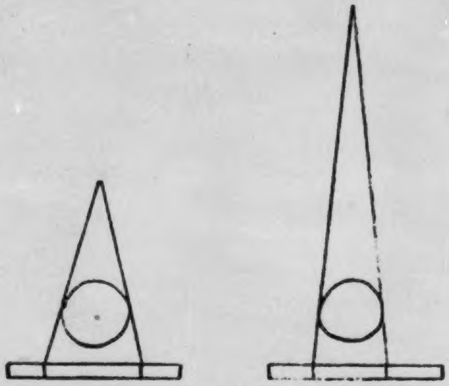
(1) Explanation - changing only the size of the object (usually blowing it up).

(2) Primary Factors Affecting Magnified Distortion

QUESTION: Which primary factors affect magnified distortion?

ANSWER: FFD only.

NOTE: Use the following illustration to explain the effects of FFD.



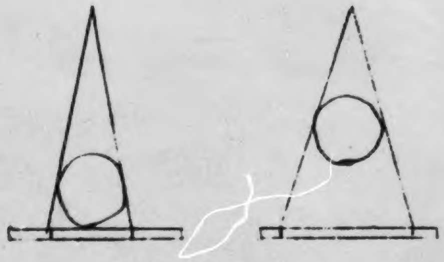
QUESTION: Can we have an exposure with no magnification?

ANSWER: No, because X-rays pass through the part and always spread out somewhat before reaching the film (divergence).

QUESTION: Why do kVp and mA not affect distortion?

ANSWER: OFD.

NOTE: Use the following illustration in your explanation.



b. True Distortion

NOTE: Show films from packet F-38-520-013-10 through 12

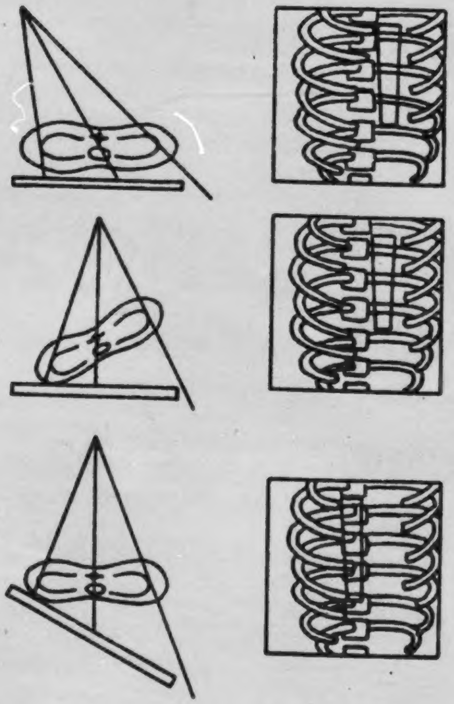
1. Explanation: Change both size and shape of an object.

QUESTION: In order to produce true distortion, what is necessary?

ANSWER: Angulation.

2. Auxiliary Factors Affecting True Distortion

NOTE: Use the following illustrations of angulation of the tube, part, and film.



F. Fog

NOTE: Show films from packet F-38-520-013-13. (See Annex C)

1. Definition: An additional unwanted density that appears on the film and is caused by secondary radiation reaching the film.

2. Primary Factors Affecting Fog.

422

LP 38-520-013
018

QUESTION: Which primary factors affect fog and how?

ANSWER: All of them in the same way they affect density.

3. Auxiliary Factors Affecting Fog

NOTE: Anything affecting the amount of secondary radiation reaching the film will affect fog.

a. Filters

b. Cones

c. Grids

d. OFD (increasing OFD will decrease fog)

NOTE: Use following chart in review session. Have the students fill in their charts.

	kVp Quality	mA Quantity	S Quantity	FFD Quantity	Focal Spot Size	OFD
Density	Yes-D	Yes-D	Yes-D	Yes-I	No	No
Fog	Yes-D	Yes-D	Yes-D	Yes-I	No	Yes-I
Contrast	Yes-I	No	No	No	No	No
Scale of Contrast	Yes-D	No	No	No	No	No
Detail	No	No	Yes-I	Yes-D	Yes-I	Yes-I
Magnified Distortion	No	No	No	Yes-I	No	Yes-D
True Distortion	No	No	No	No	No	No

431

ANNEX C
INSTRUCTIONAL AIDS

Secondary Factors Film File

F-38-520-013-1	kVp - Density
F-38-520-013-2	mA - Density
F-38-520-013-3	s - Density
F-38-520-013-4	FFD - Density
F-38-520-013-5	mAs - Density
F-38-520-013-6	kVp - Contrast
F-38-520-013-7	s - Detail
F-38-520-013-8	FFD - Magnified Distortion
F-38-520-013-9	OFD - Magnified Distortion
F-38-520-013-10	Tube Angulation
F-38-520-013-11	Part Angulation
F-38-520-013-12	Film Angulation
F-38-520-013-13	Fog

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X-RAY BRANCH

Secondary Factors of Exposure and Film Discussion (7 hours)

In our discussion of the primary factors of exposure, you learned that these are factors which are both adjustable on the instrument control panel and which determine both the quantity and quality of the X-ray beam. Carry this one step further; it is logical to assume that these primary factors will affect the final radiograph in some manner. When you look at the radiograph, you must assess its acceptability and you will be making your judgment on the quality of the film. Those factors which give the film its descriptive characteristics are termed secondary factors and these are density, contrast, detail, and distortion of exposure.

For the next seven hours, we will be examining the relationships between the secondary factors and the primary factors of exposure and viewing radiographs which lend supportive evidence to these relationships.

Density may be defined as the quantity of black metallic silver on the film, or simply the blackness on a radiograph. It is affected by the quantity of radiation reaching the film. Therefore, any factor affecting the amount of remnant radiation reaching the film will also affect the density of the film.

When we examine the primary factors of exposure, we find that all of them determine to some degree the amount of radiation reaching the film. kVp determines the penetrating power of the primary beam. If we increase the penetration of the beam, we will correspondingly increase the amount of radiation reaching the film and, therefore, increase the density on the film. Conversely, decreasing the kVp results in a decrease in the film density. Thus, the relationship between kVp and density is a direct one.

Milliamperage and time also affect the density on the film in a direct relationship. These factors determine the number of electrons that will travel from the cathode to the anode in the tube. As the number of electrons increases, we find that more radiation is produced, more radiation reaches the film and finally more density appears on the film. Conversely, as the number of electrons decreases, the amount of radiation produced decreases and the density on the film decreases.

FFD has no effect on either the amount or penetration of the primary beam. However, due to the inverse square law, FFD does affect the amount of remnant radiation reaching the film. Since the rays of the primary beam rapidly diverge from the focal spot, as the FFD increases there will be a smaller quantity of radiation striking a given size of surface area; i.e., the film. The opposite holds true as the FFD decreases. The closer the focal spot is to the film, the less rapidly the primary beam will diverge from this point and the more radiation will reach the film. Therefore, although FFD

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*This instructor's manuscript supersedes IM 38-520-008, 094.

does not affect the quantity of radiation produced, it does affect the amount of radiation reaching the film which, in turn, determines the density. As we have seen, the relationship is an inverse one. NOTE: Explain and discuss radiographs showing the effects of kVp, mA, FFD, and s on density. Also, note that small changes in kVp result in greater changes in density than corresponding changes in mAs.

Radiographic contrast is defined as the difference in tonal value found on a radiograph. There must be at least two different densities on a radiograph before it can possess contrast. The number of densities beyond these initial two determines the type of contrast. If a radiograph displays only a few different densities, there will be a great difference in the tonal values. This type of film would exhibit high contrast (great differences in tonal value) and short scale contrast. Scale of contrast is defined as the sum of all tonal values on a film. The fewer tonal values, the shorter the scale of contrast. Therefore, a film demonstrating high contrast will also demonstrate a short scale of contrast. As the contrast decreases, the scale of contrast will become longer.

There is only one primary factor which affects contrast and that is the kVp. As kVp increases, the penetration of the beam increases and the number of tonal values increases. As the number of tonal values increases, the contrast between these tonal values will decrease. Therefore, as the kVp increases, the contrast decreases. The converse is also true and thus the relationship between kVp and contrast is an inverse one. As kVp increases, contrast decreases. As kVp decreases, contrast increases.

NOTE: Explain and discuss radiographs showing the effect of kVp on contrast.

Detail on the film is described as the sharpness of the image. There are two primary factors which affect detail. These are time and FFD.

The largest enemy of radiographic detail is that of motion. When an object moves during the exposure, it spreads its image over an area larger than the object itself. The borders will appear to be unsharp. This fuzziness of the borders is known as penumbra. The duration of the exposure plays an important role in determining the detail of a radiograph. Using a shorter time of exposure gives the patient less time to move. Therefore, the shorter the duration of exposure, the better the detail provided the patient does not move. It must be emphasized that unless there is movement on the part, "time" has no affect on detail. As is seen, the relationship between detail and time is inverse.

The effect of FFD on detail goes back in part to the inverse square law. We know that as FFD increases, the rays become more divergent so that less radiation will strike a given surface area. However, under these conditions, the only rays that strike the film are those which are most perpendicular to the film. Therefore, these perpendicular rays will project a truer image to the film. As the FFD decreases. we will have more and more of the divergent rays striking the film and, therefore, the image detail will decrease. Hence, the relationship between radiographic detail and FFD is direct.

NOTE: Explain and discuss radiographs showing the effect of time and FFD on radiographic detail.

The last secondary factor is distortion. The definition of distortion is "alteration of either the size or the shape, of an image, or both." There are two types of distortion. Magnified distortion is caused by altering the size only. This can be done by decreasing the FFD or by increasing the OFD (object film distance). It is possible to compensate for an increased OFD by increasing the FFD. This will decrease the size of the image and at the same time will improve the detail. The second type of distortion is called true distortion. This involves changing of the size and shape of the image and can be accomplished by angling either the tube, the part, or the film. On certain views it is essential to cause true distortion in order to demonstrate structures that would otherwise be superimposed. The appearance of an image possessing true distortion is that of elongation. All structures appear to be longer than they really are.

NOTE: Explain and discuss radiographs showing the effect of FFD and OFD on magnified distortion and angulation of the tube, part, or film on true distortion.

There is one final category that will determine radiographic quality. That is fog and it is called an auxiliary secondary factor. Fog is defined as unwanted density that appears on the film and is caused by secondary radiation reaching the film. Any factor that increases the amount of secondary radiation reaching the film will also increase the amount of fog. All the primary factors affect secondary radiation fog: kVp because it determines the energy of the primary beam and, therefore, the energy of the secondary scatter; mAs because it determines the total amount of radiation produced; and FFD because it determines the total amount of radiation which will eventually reach the film.

Any device which will reduce the amount of secondary radiation reaching the film will, therefore, reduce the amount of fog. Several such methods are available. Grids are useful because they will absorb most of the secondary scatter. Cones and collimators are useful since they reduce the amount of radiation striking the part. Finally, filters may be used since their function is to remove the long wavelength low penetrating portion of the primary beam. This portion of the beam is responsible for a large part of the secondary scatter radiation produced.

NOTE: Explain and discuss radiographs showing the effect of fog on the film.

There are many other factors which have some effect on the secondary factors. These are called auxiliary factors. There are four principal auxiliary factors (focal spot, OFD, method of processing, and the type of film holder) which have the greatest effect on the quality of the radiograph

The focal spot of the tube has an effect on the detail of the image. The smaller the focal spot, the better the detail will be.

The second factor is OFD. We have already stated that the distance between the object and the film is called object film distance. This factor affects two secondary factors. First, if the OFD is increased, it will increase magnified distortion, and second, it will decrease the radiographic detail. An increase in OFD will decrease the amount of fog reaching the film. This is referred to as an "air-gap" technique.

Methods of processing the film will have an effect on both density and contrast. This will be dealt with later when we discuss darkroom processing.

Film holders also affect detail and contrast of the film. When using a cardboard holder, the detail will improve, but you must use a long exposure. When using a screen, the exposure time is greatly reduced, but the detail is somewhat less.

The relationships between the primary and secondary factors are extremely important. Your knowledge of the interrelations will determine to a large extent the success or failure of each radiographic exposure. Furthermore, by being able to recognize the secondary factor, you will be able to evaluate the quality of your work and determine its acceptability.

428

ACADEMY OF HEALTH SCIENCES *LP 38-520-014
MEDICINE AND SURGERY DIVISION 028
X-RAY BRANCH

Compensation Factors (4 hours)

COURSES PRESENTED TO: 313-91P10, X-Ray Specialist

PLACE: Classroom

REFERENCES:

TM 8-280, pp 6-8 - 6-30 and 6-46 - 6-49

STUDY ASSIGNMENT: After class, study and memorize compensation factors in GR 38-520-001-1B.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280

TOOLS, EQUIPMENT, AND MATERIALS: GR 38-520-001-1B issued at beginning of fourth week (one per student)

PERSONNEL: One instructor, 91P2H/91P3H/91P4H

INSTRUCTIONAL AIDS: Chalk, chalkboard, illuminators, pointer, overhead projector, radiographs.

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Lecture (4 hours)

I. INTRODUCTION (5 min)

A. Opening Statement: It is impossible for even the best of radiographic technique charts to take every possible situation into account. The trained radiologic technologist is expected to cope with a seemingly infinite number of variations from the rule in his day-to-day work. We are now going to learn the compensations for some of the most common deviations that you will encounter in your work.

B. Objectives: Given a section of a typical optimum kVp technique chart (taken from pp 35-38 of the GR) for reference and utilizing compensation factor formulas from memory, compute the new exposure, specifying the kVp, mA, s, mAs, and FFD which will be used when making changes in any one or combination of three of the following situations for any given body parts shown on the chart.

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*This lesson plan supersedes LP 38-520-011, 127.

1. Patient thickness is above or below range

2. Density: Given an underexposed or overexposed radiograph, adjust the technical factors to achieve a satisfactory density.

3. Contrast: Given a radiograph of satisfactory density

   a. Scale of contrast is to be increased or decreased

   b. Contrast is to be increased or decreased

4. The patient has a wet or dry cast on the part to be radiographed

5. A change in grids is to be made to include any of the following:

   a. Change from any grid ratio (5:1, 6:1, 8:1, 12:1, 16:1) to a nongrid technique

   b. Change from a nongrid to any grid ratio

   c. Change from one grid ratio to another grid ratio

6. Age and physical condition (children, aged, bedridden, pathology) are not normal

C. Class Procedure and Lesson Tie-in: None

II. EXPLANATION (170 min)

A. Part Thickness Compensations

NOTE: See Annex A and follow printed outline (refer students to GR 38-520-001-1B, page 15, and have them fill in their notes as per Annex A).

NOTE: Radiographs lettered A through I may be shown at appropriate points as lesson is developed (see Annex B).

1. Application

2. Compensation factors

   a. Below range

   b. Above range

3. Problems

B. Density

1. Application

2. Compensations

   a. kVp

QUESTION: What percentage change in mAs will produce a noticeable effect on the film?

ANSWER: 20%.

   b. mAs

NOTE: If the kVp is in the optimum kVp range, then compensation for density should always be done in mAs.

3. Problems

C. Contrast

QUESTION: Which primary factor determines the contrast of the radiograph?

ANSWER: kVp

1. Types
   a. High contrast
   b. Low contrast
2. Application
3. Compensation factors
   a. High contrast
   b. Low contrast
   c. 50/15 rule
4. Problems

D. Casts

1. Application
2. Compensation factors
   a. Dry cast
   b. Wet cast

NOTE: A wet cast is one that is less than 24 hours old.

431

NOTE: All changes in exposure to compensate for casts will be made in kVp unless the resulting exposure cannot safely be used on the particular machine in use. Only then should the mAs be changed.

3. Problems

E. Grids

1. Application

QUESTION: What does the grid ratio tell us about a grid?

ANSWER: The relationship between the height of the lead strips to the distance between them.

2. Compensation factors
    - a. 5:1
    - b. 6:1
    - c. 8:1
    - d. 12:1
    - e. 16:1

3. Problems

F. Miscellaneous (age, physical condition, pathology)

1. Children
    - a. Application
    - b. Compensation factors
        - (1) 0-2 years old
        - (2) 2-5 years old
        - (3) 5-12 years old

2. Elderly
    - a. Application
    - b. Compensation factors
        - (1) Aged

432

(2) Bedridden

3. Pathology

a. Less density

b. More density

4. Problems

G. Questions from Students

III. SUMMARY (5 min)

A. Review of Main Points

1. Patient thickness

2. Density

3. Contrast

4. Casts

5. Grids

6. Miscellaneous

B. Closing Statement: For many technicians entering practical work in the field of X-ray technology, a lack of knowledge of techniques is among their biggest weaknesses. During the last four hours, you have been presented with some key concepts in this area. With these compensation factors, you will be able to adjust to almost any change in X-ray exposure you may encounter.

ANNEX A
INSTRUCTIONAL AIDS

Compensation Factors

Objectives: Given a section of a typical Optimum kVp Technique Chart (taken from pp 35 - 38 of the GR) for reference and utilizing Compensation Factor Formulas from memory, compute the new exposure, specifying the kVp, mA, s, mAs, and FFD which will be used when making changes in any one or combiration of up to three of the following situations for any given body part shown on the chart.

1. Patient thickness is above or below normal range.

2. Density: Given an underexposed or overexposed radiograph, adjust the technical factors to achieve a satisfactory density.

3. Contrast: Given a radiograph of satisfactory density:

   a. Scale of contrast is to be increased or decreased.

   b. Contrast is to be increased or decreased.

4. The patient has a wet or dry cast on the part to be radiographed.

5. A change in grids is to be made to include any of the following:

   a. Change from any grid ratio (5:1, 6:1, 8:1, 12:1, 16:1) to a nongrid technique.

   b. Change from a nongrid to any grid ratio.

   c. Change from one grid ratio to another grid ratio.

6. Age and physical condition (children, aged, bedridden, pathology) are not normal.

Part Thickness Compensations:

1. Application: Approximately 85% of the general population falls into the normal (average) part thickness range, but the other 15% are thicker or thinner than normal and require a corresponding adjustment in technique.

2. Compensation Factors:

Chart Relating Adult Exposure According to Part Thickness

Thickness Range	BELOW		NORMAL	ABOVE	
	3 - 5 cm	1 - 2 cm	In Range	1 - 2 cm	3 - 5 cm
Compensation	1/2xs or 1/2mAs	2/3xs or 2/3mAs	Basic mAs*	1 1/2xs or 3/2mAs	2xs or 2xmAs

*For compensations above and below range, the change in mAs may be made by changing either mA or s. In practice, these changes are usually made in s only. For above range parts, it would be desirable to make the changes in mA if this is possible (e.g., if such a setting exists) without going to a larger focal spot so we can use a shorter exposure time. In a normal situation, the change ordinarily must be made in s.

3. Problems

a. Given: 80 kVp, 50 mA, 1/2 s, 40" FFD
Average Thickness - 12 to 15 cm

*(1) Patient measures 2 cm below range.
80 kVp 50 mA 1/3 s

(2) Patient measures 18 cm.
80 kVp 50 mA 1 s

*(3) Patient is 1 cm above range.
80 kVp 50 mA 3/4 s

b. Given: 75 kVp, 30 mAs
Average Thickness - 10 to 14 cm

*(1) Patient measures 6 cm.
75 kVp 15 mAs

(2) Patient is 2 cm above range.
75 kVp 45 mAs

Density:

1. Application: With the most accurate of technique charts, it is still frequently necessary to compensate for a radiograph which is either too dark (overexposed) or too light (underexposed).

2. Compensations: If it has been determined that a radiograph requires a change in density, first check the kilovoltage. If the kVp is not in the optimum recommended range for the part, it should be adjusted. The effect of this change on the desity for the radiograph is based on the following chart.

Chart relating kVp to density

1/2 Density	Original Density	Double Density
.85 x kVp or kVp - 15%	kVp used	1.15 x kVp or kVp + 15%

Normally, the best way to correct the density of the radiograph is in mAs.

Chart Relating mAs to Density

1/2 Density	Original Density	Double Density
1/2 mAs	mAs used	2 x mAs

NOTE: A 20% change in the mAs will make a noticeable change in the density. To get a satisfactory density on the film, the following steps are necessary.

1. For overexposure
   a. 1/2 mAs
   b. Make minor adjustments between 20% - 80% to achieve satisfactory film.
2. For underexposure
   a. 2 x mAs
   b. Make minor adjustments between 20% - 80% to achieve satisfactory film.
3. Problems

a. The quality control technician has just returned a radiograph to you and told you that it is too dark. The position is an AP pelvis. The technique used was 70 kVp, 300 mA, 2/5 s, 40" FFD.

*(1) What technique will you use to obtain a lighter film?
70 kVp 60 mAs

(2) The repeat is a little too light, make a minor adjustment for greater density.
70 kVp 72 mAs

b. An AP shoulder taken at 70 kVp, 200 mA, 1/10 s is too light.

*(1) What technique will you use to compensate?
70 kVp 40 mAs

(2) The second film is slightly too dark, make a minor adjustment in density.
70 kVp 32 mAs

c. A transthoracic humerus was taken at 90 kVp, 200 mA, 1/2 s, 40" FFD.

*(1) The film is too dark, compensate.

90 kVp 50 mAs

(2) The second film is too dark, compensate

90 kVp 25 mAs

*(3) The third film is too light, make a minor adjustment to the density.

90 kVp 30 mAs

(4) The film is still too light, make a minor adjustment to the density.

90 kVp 36 mAs

d. A PA hand was taken at 50 kVp, 25 mA, .05 s, it is too dark. No lower machine adjustments can be made in mAs.

*(1) What technique will you use?

42.5 kVp 1.25 mAs

Contrast:

1. Types - review
   a. High contrast - short scale (fewer shades of gray)
      (More contrast)
      (Greater contrast)
   b. Low contrast - long scale (more shades of gray)
      (Less contrast)
2. Application
   a. To better visualize certain types of pathology
      (1) Higher contrast-foreign body localization, soft tissue
      (2) Lower contrast-tumors
   b. To maintain density while altering contrast
3. Compensation Factors

Chart Relating Contrast Changes Keeping Density Constant

Lower Contrast (Longer Scale)	Higher Contrast (Shorter Scale)
1.15 x kVp	.85 x kVp
1/2 x mAs	2 x mAs

NOTE: The above chart expresses the 50/15 rule for changes in contrast which states that to change the contrast while maintaining the density, the kVp is changed by a factor of 15% and the mAs is either 50% or doubled.

4. Problems

a. Given: 70 kVp, 30 mAs, 40" FFD

*(1) Produce a shorter scale of contrast
60 kVp 60 mAs

(2) Produce a higher contrast
60 kVp 60 mAs

*(3) Produce a lower contrast
81 kVp 15 mAs

*(4) Produce a longer scale of contrast
81 kVp 15 mAs

b. Produce greater contrast with each of the following exposures:

*(1) 80 kVp, 100 mA, 3/10 s, 40" FFD
68 kVp 60 mAs

(2) 60 kVp, 50 mA, 3/20 s, 36" FFD
51 kVp 15 mAs

*(3) 75 kVp, 25 mA, 1/5 s, 40" FFD
64 kVp 10 mAs

(4) 90 kVp, 5 mA, 1/2 s, 30" FFD
77 kVp 5 mAs

c. Produce a longer scale of contrast with each of the following exposures:

*(1) 60 kVp, 100 mA, 3/20 s, 30" FFD
69 kVp 7.5 mAs

(2) 75 kVp, 50 mA, 3/10 s, 40" FFD
86 kVp 7.5 mAs

(3) 90 kVp, 25 mA, 1/5 s, 30" FFD
104 kVp 2.5 mAs

(4) 80 kVp, 5 mA, 1/2 s, 40" FFD
92 kVp 1.25 mAs

Casts:

1. Application: The addition of plaster or other cast material requires

additional exposure to compensate for the density loss on the film.

2. Compensation Factors

Chart Relating Changes In
Exposure Because Of Casts

Dry Cast	+ 15 kVp	OR	2.5 x mAs
Wet Cast	+ 20 kVp	OR	3.5 x mAs

NOTE: A wet cast is one that is less than 24 hours old.

NOTE: All changes in exposure to compensate for casts will be made in kVp unless the resulting exposure cannot safely be used on the particular machine in use. Only then should the mAs be changed.

3. Problems

a. Compensate for a dry cast in each of the following exposures. Assume a safe limit of 90 kVp.

*(1)	70 kVp, 20 mAs, 40" FFD	85 kVp 20 mAs
(2)	80 kVp, 10 mAs, 30" FFD	80 kVp 25 mAs
*(3)	60 kVp, 15 mAs, 36" FFD	75 kVp 15 mAs
(4)	75 kVp, 2.5 mAs, 40" FFD	90 kVp 2.5 mAs
*(5)	65 kVp, 12.5 mAs, 30" FFD	80 kVp 12.5 mAs

b. Compensate for a wet cast in each of the following exposures. Assume a safe limit of 90 kVp.

(1)	75 kVp, 15 mAs, 36" FFD	75 kVp 53 mAs
*(2)	60 kVp, 10 mAs, 40" FFD	80 kVp 10 mAs

(3) 80 kVp, 2.5 mAs, 30" FFD
80 kVp 9 mAs

*(4) 70 kVp, 20 mAs, 40" FFD
90 kVp 20 mAs

(5) 65 kVp, 25 mAs, 30" FFD
85 kVp 25 mAs

Grids:

1. Application: Technique charts specify the use of a grid of a certain ratio. There are many times when the situation will alter either the grid ratio or the ability to use one at all. Compensation must be made for these circumstances.

2. Compensation Factors

Chart Relating Changes in
Exposure Because Of Grids

Type of Grid	From Nongrid to Grid	Removing Grid
5:1	+15 kVp or 2.5 x mAs	-15 kVp
6:1	+15 kVp or 2.5 x mAs	-15 kVp
8:1	+20 kVp or 3.5 x mAs	-20 kVp
12:1	+25 kVp or 4.5 x mAs	-25 kVp
16:1	+30 kVp or 5.5 x mAs	-30 kVp

NOTE: All changes in exposure to compensate for grids will be made in kVp unless the resulting exposure cannot safely be used on the particular machine in use. Only then should the mAs be changed.

3. Problems

a. Compensate as indicated for the following exposures. Assume a machine limit of 95 kVp.

*(1) 50 kVp, 10 mAs, nongrid - change to - 5:1
65 kVp 10 mAs

*(2) 75 kVp, 5 mAs, nongrid - change to - 8:1
95 kVp 5 mAs

*(3) 80 kVp, 25 mAs, 8:1 - change to - nongrid
60 kVp 25 mAs

(4) 60 kVp, 15 mAs, nongrid - change to - 5:1
75 kVp 15 mAs

*(5) 65 kVp, 40 mAs, 5:1 - change to 8:1
70 kVp 40 mAs

(6) 85 kVp, 7.5 mAs, 16:1 - change to - 5:1
70 kVp 8 mAs

b. Compensate ONLY as indicated for the following exposures. Assume a machine limit of 95 kVp.

*(1) 70 kVp, 10 mAs, 8:1 - to - nongrid and wet cast
70 kVp 10 mAs

(2) 60 kVp, 25 mAs, 5:1 - to - 16:1
75 kVp 25 mAs

(3) 50 kVp, 5 mAs, nongrid - to - 16:1 and dry cast
95 kVp 5 mAs

*(4) 80 kVp, 15 mAs, 8:1 - to 5:1 and dry cast
90 kVp 15 mAs

*(5) 50 kVp, 10 mAs, nongrid - to - 8:1
70 kVp 10 mAs

*(6) 75 kVp, 5 mAs, nongrid - to - 16:1
75 kVp 28 mAs

Miscellaneous (Age, Physical Condition, Pathology):

1. Children

a. Application: Technique charts do not always have the technique for children written on them.

b. Compensation Factors

Chart Relating Changes in Exposure Because of Age

Age	Factor
0-1 Years	1/4 mAs
2-4 Years	1/3 mAs
5-12 Years	1/2 mAs

2. Elderly

a. Application: As our age advances into the "twilight" years, our bodies begin to metabolically deteriorate, muscles atrophy and bones decalcify.

b. Compensation Factors: Aged individuals from about 55 years of age may require a reduction of exposure of 1/2 to 1/3 the normal adult exposure, depending upon the body aging conditions. (Patients bedridden over six months require 1/2 basic mAs.)

3. Pathology

a. Application: Certain pathological conditions require either an increase in technique or a decrease in technique to satisfactorily demonstrate the anatomical area of interest.

b. Compensations: Pathological conditions are listed by those which require a decrease in technique and those which require an increase in technique, normally compensations are made in mAs.

Conditions which require 2 x mAs	Conditions which require 1/2 x mAs
Sclerosis	Destructive bone diseases
Fluid or Pus	Malnutrition
Contrast Media	Atrophy
	Malignant metastases
	Emphysematous tissue
	Arthritis

4. Problems

a. Given adult exposure of 70 kVp, 100 mA, 1/5 s, 40" FFD, what exposure would you use for the following:

(1) Child seven years old
70 kVp 10 mAs

*(2) Infant 18 months old
70 kVp 5 mAs

(3) Girl nine years old
70 kVp 10 mAs

*(4) Boy three years old
70 kVp 6.7 mAs

b. Given adult exposure of 65 kVp 200 mA, 3/4 s, 40" FFD, what exposure would you use for the following:

*(1) 60-year-old man
65 kVp 75 mAs

(2) 83-year-old invalid, bedridden two years
65 kVp 37.5 mAs

(3) 40-year-old adult, bedridden seven months
65 kVp 75 mAs

*(4) Patient has fluid present
65 kVp 300 mAs

NOTE: All of the compensation factors in this section are for use with Optimum kVp Technique ONLY.

ANSWERS (FOR ALL UNSTARRED PROBLEMS)

Page A-2, para 3:

a(2) 80 kVp, 50 mAs
b(2) 75 kVp, 45 mAs

Pages A-3 & A-4, para 3:

a(2) 70 kVp, 72 mAs
b(2) 70 kVp, 32 mAs
c(2) 90 kVp, 25 mAs
(4) 90 kVp, 36 mAs

Page A-5, para 4:

a(2) 60 kVp, 60 mAs
b(2) 51 kVp, 15 mAs
(4) 76 kVp, 5 mAs
c(2) 86 kVp, 7.5 mAs
(3) 104 kVp, 2.5 mAs
(4) 92 kVp, 1.25 mAs

Pages A-6 & A-7, para 3:

a(2) 80 kVp, 25 mAs
(4) 90 kVp, 2.5 mAs
b(1) 75 kVp, 53 mAs
(3) 80 kVp, 9 mAs
(5) 85 kVp, 25 mAs

Page A-8, para 3:

a(4) 75 kVp, 15 mAs
(6) 70 kVp, 8 mAs
b(2) 75 kVp, 25 mAs
(3) 95 kVp, 5 mAs

Pages A-9 & A-10, para 4:

a(1) 70 kVp, 10 mAs
(3) 70 kVp, 10 mAs
b(2) 65 kVp, 37.5 mAs
(3) 65 kVp, 75 mAs

ANNEX B
INSTRUCTIONAL AIDS

Radiographs: Lateral skull

15 cm part thickness

40" FFD

2.5 mm Al

High speed screens

A.	86 kVp	200 mA	1/15 s	12.5 mAs	Overexposure
B.	86 kVp	50 mA	1/8 s	6.25 mAs	(1/2 mAs) slightly too light
C.	86 kVp	200 mA	1/24 s	8.3 mAs	(about 35% of A.) correct density
D.	86 kVp	300 mA	1/60 s	5 mAs	(too light)
E.	86 kVp	300 mA	1/30 s	10 mAs	(2 x mAs) guide film for contrast
F.	98 kVp	300 mA	1/60 s	5 mAs	(5 /15) long scale contrast
G.	114 kVp	300 mA	1/120 s	2.5 mAs	2(50/15) very long scale contrast
H.	74 kVp	300 mA	1/15 s	20 mAs	(50/15) short scale contrast
I.	62 kVp	300 mA	3/20 s	45 mAs	(50/15) very short scale contrast

ACADEMY OF HEALTH SCIENCES *IM 38-520-014
MEDICINE AND SURGERY DIVISION 028
X-RAY BRANCH

Compensation Factors

It is impossible for even the best of radiographic technique charts to take every possible situation into account. The trained radiologic technologist is expected to cope with a seemingly infinite number of variations from the rule in his day-to-day work. We are now going to learn the compensations for some of the most common deviations that you will encounter in your work.

Frequently, the technique chart, which is provided in the exposure room, gives techniques only for those patients who are in the average range. Should this be the case, you will have to adjust the technique each time you have a patient who is not within the average range given. The following formulas may be used to compensate for this: three to five centimeters below range, one-half s, or one-half of mAs; one to two centimeters below range, two-thirds s, or two-thirds of mAs; in range use basic mAs; one to two centimeters above range, one and a half s, or three halves mAs; three to five centimeters above range, two times s, or two times mAs. For compensations above and below range, the change in mAs may be made by changing either mA or s. In practice, these changes are usually made in s only. For above range parts, it would be desirable to make the changes in mA if this is possible; e.g., if such a setting exists without going to a larger focal spot so we can use a shorter exposure time. In a normal situation, the change ordinarily must be made in s. We will now work some problems using these compensations. Refer to page sixteen in your general reference.

One of the most common problems that you will encounter is the need to correct a radiographic technique which has produced a radiograph that is overexposed (too dark) or underexposed (too light). The first step in correcting this problem is to determine if the incorrect exposure is due to an error in kilovotage or mAs. While it is possible for the experienced technician to determine the need to adjust the contrast rather than the density by inspecting the radiograph, the best place to start is by reviewing the technique used for the first film. If the recommended optimum kVp technique has been used, the technologist can assume that adequate penetration of the part has been achieved, and an acceptable scale of contrast has been obtained. However, should you discover that it is necessary for you to change the kVp, then you should be familiar with the effect of kVp on density. A chart has been provided which illustrates the relationship which exists between kVp and density. For example, if you multiply the kVp by eighty-five hundredths or reduce it by fifteen percent, you will reduce the density by half. If you multiply the kVp by one point fifteen or increase it by fifteen percent, you will have doubled the density. Normally, however, the best way to correct the density of the radiograph is in mAs. This is done because the kVp affects the contrast as well as the density. MAs is related to density in approximately a one-to-one basis. If you want to halve the density, you must halve the mAs.

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*This instructor's manuscript supersedes IM 38-520-011, 127.

If you want to double the density, you must double the mAs. Referring back to your class on secondary factors of exposure, how much of a change in mAs is required to produce a noticeable change in density on the radiograph? The correct response is that at least a twenty percent change in mAs is required to produce noticeable change in density on the film. The following steps are, therefore, necessary to achieve a properly exposed radiograph: If the first attempt is overexposed, the technician should reduce the mAs by one-half; if the second film is acceptable, go on to the next procedure; if not, minor adjustments to technique must be made by increasing or decreasing the mAs used for the second exposure by a factor of twenty to eighty percent. The third radiograph is usually satisfactory. If the first radiograph is underexposed, you begin correcting by doubling the mAs. The instructions for making minor adjustments are the same as for the overexposed film.

Another common situation is the one in which you receive an X-ray request which requires you to take a radiograph with a different contrast than that which you normally use, or the radiologist requests a change in contrast to better demonstrate some suspected pathology. Since you are aware of the fact that kVp is the only primary factor that affects the contrast of a radiograph, you realize that you must change the kVp in order to satisfy the request. However, as we have just demonstrated, kVp also affects density and we do not want to alter the density in this case. Therefore, we will have to alter the contrast without changing the density. First, let's review what we already know about contrast. We refer to a radiograph as having either high contrast or low contrast. An X-ray which has high contrast may also be said to have short scale contrast or more contrast (few shades of grey). Low contrast is also said to be long scale contrast or less contrast (many shades of grey). Alterations in contrast are used to improve the visualization of certain types of pathology (e.g., higher contrast for foreign body localization or soft tissues, lower contrast for tumors). A chart is provided which shows you how to alter contrast while keeping density constant. For lower contrast you must multiply the kVp by one point fifteen or add fifteen percent to it. To maintain the density of the film, you must then reduce the mAs by one-half. To obtain higher contrast, you should multiply the kVp by point eight five or subtract fifteen percent from it, and double the mAs to maintain density. This procedure may be summarized as the 50/15 rule for changes in contrast which states that to change the contrast while maintaining density, the kVp is changed by a factor of 15 percent and the mAs is either halved or doubled.

Whenever you work with the orthopedic department, one of the most frequent compensations you will need to make is for the patient with a cast overlying the part to be radiographed. This addition of plaster or other cast material requires additional exposure to compensate for the density loss on the film. Casts are either classified as wet or dry cast. For a dry cast, we add fifteen kVp to the technique or increase to mAs by two point five. For a wet cast, twenty kVp is added to the regular technique, or the technique is multiplied by three point five. Remember, we define a wet cast as one which has been on the patient less than 24 hours. All changes in exposure to compensate for casts will be made in kVp unless the resulting exposure cannot safely be used on the particular machine in use. Only then should the mAs be changed.

Technique charts specify the use of a grid of a certain ratio. There are many times when the situation will alter either to grid ratio or the ability to use one at all. Compensations must be made for these circumstances. Refer to your GR and fill in the following factors. For each grid ratio given, the first correction factor is from nongrid to the specified grid. The second factor is used to correct the situation in which the chart calls for a grid and it cannot be used. For a five to one grid, add fifteen kVp or two point five times the mAs; to remove it, subtract fifteen kVp. For a six to one, the same factors apply. For an eight to one, add twenty kVp or three point five times the mAs; to remove it, subtract twenty kVp. For a twelve to one grid, add twenty-five kVp or four point five times the mAs; to remove it, subtract twenty-five kVp. For a sixteen to one grid, add thirty kVp or five point five times the mAs; to remove it, subtract thirty kVp.

Among the other compensations you will need on a day-to-day basis in the clinic are: age, physical condition, and pathologies. Small children, for example, are rarely taken into account on the chart in your room. As a guideline for child techniques - from zero to one years of age, use one-quarter of the mAs; from two to four, one-third of the mAs; from five to twelve, use one-half the mAs.

As our age advances into the "twilight" years, our bodies begin to metabolically deteriorate, muscles atrophy, and bones decalcify. Therefore, older individuals from about fifty-five years of age may require a reduction of exposure of one-half to one-third the normal adult exposure - depending on the body aging conditions. The exact amount of reduction is a judgement factor which you will learn as you gain in experience in the clinic. In addition to this, patients who have been bedridden over six months require a reduction to one-half the basic mAs.

Pathological conditions are divided into those which require an increase in technique and those which require a decrease. The amount of change is only representative since the progress of the condition will have some bearing on the extent of technique change required to produce a satisfactory film. Conditions for which you should double the mAs are: sclerosis, fluid or pus, and contrast media (sometimes require a change in kVp). Conditions which would normally require one-half the mAs are: destructive bone diseases, malnutrition, atrophy, malignant metastases, emphysematous tissue, and arthritis.

I want to remind you that all the compensations discussed in this class are for optimum kVp techniques only.

During the last four hours we have discussed the compensation factors used to correct for patient thicknesses which are out of the average centimeter range of the chart. Remember to make these changes in time (s) whenever possible. Changes to correct for density errors on the film are usually made in mAs. For a light film, double the mAs; and on a dark film, halve the mAs. Contrast can be adjusted by following the fifty/fifteen rule. For casts, the compensation is to add fifteen kVp for a dry cast and twenty kVp for a wet cast. The compensations for grids are directly related to grid ratio and

447

should always be made in kVp whenever possible. Other compensations we have discussed are those for children, elderly, bedridden, or pathological conditions.

For many technicians entering practical work in the field of X-ray, a lack of knowledge of techniques is among their biggest weaknesses. During the last four hours you have been presented with some key concepts in this area. With these compensation factors, you will be able to adjust to almost any change in X-ray exposure you may encounter.

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

Mr. John Mayes
*LP 38-520-010
036

Radiographic Exposure Technique (5 hours)

COURSES PRESENTED TO: 313-91P10, X-Ray Specialist

PLACE: Classroom

REFERENCES:

TM 8-280
Cahoon, John B, Jr., Formulating X-Ray Techniques. Sixth Ed., Durham, N.C.: Duke University Press, 1966, pp 137-228.
Kratzer, Brice, A Technique Computer: Scientific Approach to Radiologic Technology, Radiologic Techniques, Vol 45, No. 3, Nov/Dec 1973, pp 142-150.
Selman, Joseph, The Fundamentals of X-Ray and Radium Physics, 5th Springfield, Illinois, Charles G. Thomas, Publisher, 1972, p. 317.

STUDY ASSIGNMENT: Before class read TM 8-280, pp 6-42 to 6-49, para 6-36 thru 6-37.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280, GR 38-520-001-1B

TOOLS, EQUIPMENT AND MATERIALS: None

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Chalk, chalkboard, and eraser; Sample Optimum kVp and variable kVp technique charts; "Supertech" - one each student; Training Aid mock-up of "Supertech".

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Lecture (1st, 2d & 3d hr) Practical Exercise (4th & 5th hr)

I. INTRODUCTION (10 min)

A. Opening Statement: The most challenging aspect of the radiological technician's job is determining exposure factors. Exposure factors regulate the amount and type of radiation received by the patient as well as governing the quality of the film itself. As an X-ray Specialist, your job is to select the best factors, considering both patient safety and film quality.

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*This lesson plan supersedes *LP 38-520-010, 082

449

B. Objectives

1. State the differences which exist between:

   a. The theories of Variable kVp and Optimum kVp formats.
   b. Typical Variable kVp and Optimum kVp formats.

2. List at least three advantages of Optimum kVp over Variable kVp techniques.

3. Determine the "proper" exposure to be used for a given body part when given a specific technique chart or "Supertech" slide rule.

C. Class Procedure and Lesson Tie-in

Present "Supertech" as a practical exercise.

II. EXPLANATION (115 min)

NOTE: Refer to Annex A and follow printed outline (Students using GR 38-520-001-1 have major underlined headings filled in and must fill in their notes as per Annex A).

A. Standardization and Control in Radiography

B. Radiographic Quality

C. Factors to be considered in formulating a technique

D. Methods for selecting technique factors

E. Comparison of Variable kVp Optimum kVp

F. Advantages of Optimum kVp

G. Setting up an Optimum kVp chart

H. "Supertech"

I. Questions from Students.

450

III. SUMMARY (10 min)

A. Review of Main Points

1. The theory of Variable kVp technique selection.

2. The theory of Optimum kVp technique selection.

3. Advantages of Optimum kVp.

4. Use of Supertech.

B. Closing Statement: As has been seen, the method of selecting technique factors is a complex procedure. It requires you, the X-ray Specialist, to make important decisions which safeguard your patient and result in the highest quality radiographs which could be attained. Therefore, treat the selection of technique factors as a science to insure both high quality radiographs and minimal patient exposure to x-radiation. It is recommended that you use "Supertech" or technique chart based on "Supertech" in the absence of any prescribed chart on the job. Correct use of "Supertech" will give all the advantages of Optimum kVp and give consistently better quality of films than almost any other system now in use. In the case that a given chart is required in a specific clinic use that chart unless you receive permission to do otherwise.

ANNEX A
INSTRUCTIONAL AIDS

Radiographic Exposure Technique

A. Standardization & Control in Radiography

1. Exposure should be standardized so that the overall density and contrast of every film is uniformly acceptable to the Radiologist who reads the films.

2. Film processing should be uniform so that all correctly exposed films are uniformly acceptable to Radiologist.

B. Radiographic Quality (Secondary factors)

1. Detail - maximum sharpness

2. Distortion - minimum - as close to true size as possible.

3. Fog - at minimum.

4. Density.

   Overall density - no blacks - no whites.

5. Contrast.

QUESTION: What type of contrast does this imply is most desirable?

ANSWER: Long scale or high contrast.

C. Factors to be considered in formulating a technique

1. Type of film holder - screens

2. Grid used
   a. Ratio
   b. Radius

3. Machine used
   a. Tube limits: kVp, mA
   b. Tube rating chart
   c. Exposure settings

460

4152

(1) kVp

(2) mA

(3) s

d. Rectification

4. Processing

5. Patient thickness

QUESTION: Which of these factors should be listed on the technique chart?

ANSWER: All except tube rating chart and processing.

D. Methods for selecting technique factors

1. Body habitus - Use different techniques for different basic body structures. (heavyset, normal, slender) Little used - Difficult to use.

2. High voltage (super voltage) 100-200 kVp or up.

3. Variable kVp - Change kVp for different part thickness. Keep mAs, FFD constant regardless of thickness.

4. Optimum kVp - Change mAs for different part thickness. Keep kVp, FFD constant regardless of thickness.

5. "Supertech" - an Optimum kVp exposure slide rule usable with variable kVp technique.

6. Automated Exposure - machine sets kVp, mA, s for each patient - technician positions patient and sets FFD.

E. Comparison of Variable kVp to Optimum kVp

	Variable kVp	Optimimum kVp
Constants:	mA s FFD	kVp FFD
Variables:	kVp	mA s
Comparisons:	Lower kVp Higher mAs Longer s Changeable contrast Shorter scale contrast	Higher kVp Lower mAs Shorter s Constant contrast Longer scale contrast

F. Advantages of Optimum kVp

1. More information on smaller chart
2. Easier to use.
3. Consistent, lower contrast.
4. Greater latitude of exposure.
5. Shorter s, better detail.
6. Less heat units - longer tube life.
7. Less patient dose.

QUESTION: With all these advantages, why isn't Optimum kVp used more?

ANSWER: (1) Medical procedures cannot be forced by regulation.
(2) Variable kVp is the traditional method and is very slow to change.

G. Setting up an Optimum kVp Chart

1. Select AVERAGE range patient: On s sample areas (different patient for each area - skull, chest, spine, hip, extremity) expose the same part with 3 exposures.

  - a. mAs from sample chart (Guide mAs)
  - b. 1/2 x Guide mAs
  - c. 2 x Guide mAs

2. Let Radiologist select the film which best suits him.

3. Make intermediate exposures, IF NECESSARY, to get the best adjusted mAs.

4. Calculate Correction Factor (CF) $CF = \frac{\text{Adjusted mAs}}{\text{Guide mAs}}$

5. Multiply all mAs valves for a given body area by the CF for that area.

H. "Supertech": Operated Charts in Order

1. Chart A - Part and thickness
    - a. Measure through path of CR
    - b. Locate line on Chart A which shows desired part
    - c. Set cm measurement in appropriate window
        - (1) Black window for adults
        - (2) Red window for children under 12 years

2. Chart B - Correction Factors

    Starting point is (high speed) screens, (12:1) grid at (40") FFD unless otherwise noted on the chart.

    - a. For corrections see "Supertech" (right of Chart A)
    - b. Add all required correction factors to get Total Correction Factor (TCF)
    - c. Set TCF on Chart B.

455

3. Chart C - Exposure Technique

a. Turn over "Supertech" without moving slides.

b. Use any horizontal line matching up the kVp and mAs combination.

c. Recommended kVp is shown on Chart A in parentheses but to change contrast change kVp according to directions on back of slide B and use the mA-s combination at the new kVp.

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DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

Mr. John Mayes
*IM 38-520-010
036

Optimum KVP

The most challenging aspect of the radiological technician's job is determining exposure factors. Exposure factors regulate the amount and type of radiation received by the patient as well as governing the quality of the film itself. As an x-ray specialist, your job is to select the best factors, considering both patient safety and film quality.

To begin the process of selecting technique factors, some means of standardization and control for the field of x-ray must be considered. In x-ray, as in many areas of professionalism, there must be guidelines established. The main objective is to produce radiographs of very similar quality no matter what machine is used, where the exposure happens to be made, or what the patient might look like. If this is the ultimate, then, you will agree, some form of standardization is critical.

Where does this process of standardizing the x-ray field begin? The first thing one might think is that the position should look the same on every film of that particular part. This would then form a basis for radiologists to determine, from experience and comparison, if any pathology is present. The films must be of the same viewing angle and placement for any judgment to be made by a doctor of radiology.

A second area of consideration is in processing the films. Some control must be added to this phase of radiology since every film must be developed. A system of washes and baths are required to bring out a visible image which the doctor then interprets. It is important that, in this area of the overall x-ray cycle, the characteristics of the radiograph are not altered. The fifth week of this course will explain the guidelines established to standardize and control the processing of radiographs.

Today's topic is one of standardization and control of the exposure factors used to produce the primary beam of radiation and the radiograph. What technique is to be used? This area is probably the most difficult to control. Knowing that the ultimate is the final product, uniform quality radiographs, the job is to obtain these radiographs using today's standards. Positions are established and cannot change. Processing is 90 percent automated which means it will not vary drastically, and our end results are consistent. But in determining technique, many avenues are open which will result in diagnostic radiographs.

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*This instructor's manuscript supersedes IM 38-520-010, 082

The secondary factors of exposure give the film its descriptive characteristics. What exactly is desired of the secondary factors of exposure which appear on the film? It is not enough to have density, blackness, on a film. This blackness must be present as a translucent density in the image. You must be able to see the "light in the shadows." However, the blackness (which is deposits of silver) must be represented throughout the image. This overall image density will be produced by having full penetration of the part.

In radiographing anatomical parts for diagnosis, there must be a good definition of structures. To see this type of anatomical definition, which is critical in many cases, there must be long scale (low) contrast. Maximum sharpness and clarity are essential also. Measurements are often taken directly from radiographs for a surgical procedure. Along with this fine detail, there should be minimal distortion and minimal fogging. Therefore, high standards are demanded for the manner in which the secondary factors appear on the radiograph.

Concern now focuses on formulating an exposure technique. What factors should be considered in selecting a technique? The type of film holder, for one thing, will drastically affect the film quality. Choosing between a cardboard or a cassette holder means selecting two drastically different techniques. Even within the different speed screens, care must be taken in choosing the proper technique, for a high-speed screen with larger crystals emits more light than a slow-speed, small-crystal screen when using the same exposure factors.

Emulsion layer thickness on the film will also be a determinant in selecting exposure factors. This correlates to the use of different types of film holders. The purpose of having different types of films is so they may be used in different types of film holders. Processing will also be a variable. Will the system be automatic or manual? What type of chemicals are being used? What is the temperature of the solutions?

Grids are another factor which make adjustments in technique necessary. Grid ratios, which determine the grid's efficiency, are set up for different KVP ranges. The grid radius and the FFD should correspond for proper use of a focus grid. Determination of the number of lines (lead strips) per inch also will effect exposure technique.

Filtration and the type of coning device used become parameters for determining exposure factors. According to Army regulation, a total of 2.5 mm aluminum equivalent is required on every x-ray machine.

458

What if 3mm aluminum or 3.5mm aluminum is used? The technique must also be varied. The smaller the conefield, the less secondary radiation, thus, less density. All films should have the same density; hence, technique is altered.

One of the major problems with setting up technique is the equipment used. What is the capacity of the tube? How is electrical energy being generated? Do the machine circuits use self-rectification or full-wave? Is phasing being employed? Not only do these questions suggest changes in technique, but exactly how accurate has calibration been? If the dial is turned to 10MA, is 10 milliamperes of current flow being sent across the tube? What about duration of exposure? Is 1/10S really allowing x-rays to be produced for only 1/10 of a second?

The key still remains! The primary factors of exposure are mainly responsible for the secondary factors fo exposure. This is the basis for the technique discussion--uniform quality radiographs. How is selection of factors controlled to produce similar films?

The final area of consideration over which there is no control is the patient. This is the one variable you must work around. Everything possible must be done to protect the patient. It has been shown statistically that 85 percent of all patients are within a 6 centimeter range of similar thickness of a given part. This is really the only factor which aids technicians in formulating techniques for producing radiographs. But it is the patient who is the number one consideration when it comes to choosing a technique.

There have been six different methods established for selecting technique factors. Some are new and require mechanical adaptation to the equipment, others are old and quite complex, and two are used in the vast majority of clinics today. Much can be learned by simply studying the theory behind the different methods.

An ideal method of selecting technique is the trend toward automated exposure. With this method, all attention can be directed to the patient and his care since the factors are selected by a computerized system. Ion chambers or photo cells regulate the total density placed on the film. All that is necessary is to insert a prepunched card for the part to be radiographed and an electronic circuit controls the selection of factors. Its major use today has been with mass chest survey examinations. It is estimated that by the year 1980, this method of selecting technique will be the primary means of determining technique factors.

An old and quite complex means of selecting technique involves placing each patient in one of four size and weight categories. This body habitus method would then have a separate chart for each part in each category. The entire basis for determining what technique to use relies on a subjective opinion of the technician making the exam.

Recent trends have been toward an ultra high KVP technique. This method would use values in the range of 100 to 200 kilovolts. The advantage of a technique of this sort would be to reduce patient exposure to a minimum.

A much favored method among workers in the field has been a variable KVP selection. Using this method, the technician must measure the part to be radiographed. The technician then uses a chart which designates a KVP for each cm. of part thickness. In theory, the change in KVP changes the penetration of the beam which casts the image on the film. For thicker parts, more penetration is required; therefore, a higher KVP is used. The MAS for each exposure will remain the same. Using this method seems rather simple--read a chart, turn a dial or press a button. It is essential, however, that each part is measured and not estimated. Proper film density in this case relies only on KVP changes, and KVP changes need only be small to show a density change on the film.

Optimum KVP also requires accurate measurement of each part to be radiographed. For this method, MAS will be the variable for part thickness changes, and KVP will remain constant at an optimum or best value. This KVP will adequately penetrate a large range of thicknesses. The MAS will then be lower.

From the statistics on part thicknesses of the overall population, 85 percent of the patients will be placed in an average thickness range. The same exposure factors will be used for all patients in this category. A deviation in centimeter thickness from the norm will be adjusted by varying the MAS.

The advantages of optimum KVP far outweigh those of variable KVP selection. In comparing the two charts, the optimum KVP chart has more information than the variable KVP chart. For the 15 percent of the patients who are out of the average range of part thickness, the compensation factors learned previously will suffice in making the necessary change in exposure factors for the optimum KVP technique. In the case of variable KVP, it would be rather hard to learn or memorize a KVP for each different centimeter thickness. Thus, it seems that the optimum KVP chart is easier to use and easier to memorize.

Since KVP is constant at a higher value in the optimum KVP technique, the contrast is low and consistent on all films. With variable KVP, kilovoltage changes for each centimeter thickness so contrast changes. It would be difficult for a radiologist to make accurate diagnoses on films with contrast changes so noticeable.

The optimum KVP technique offers a greater latitude of exposure. Because KVP is constant and MAS is the variable, there can be a wider margin for error in MAS technique. Approximately a 30 percent change in MAS is required before any noticeable change in density can be viewed by the naked eye. Whereas only two kilovolts would be enough variance to see a density change on the film. Errors would be readily noticed with variable technique possibly causing a re-ray for proper film quality.

The time of exposure is generally shorter for optimum KVP because of a lower MAS. This reduces the chance of patient motion and, thus, poor detail. MAS being our quantity of radiation, it is then true that patient exposure to harmful radiation will also be less.

Finally, the heat produced at the anode during exposure has been calculated as being about 35 percent less with optimum KVP than with variable KVP for a similar exposure.

How can an optimum KVP chart be implemented in a clinical environment? To begin with, guide techniques have been established which list a guide exposure for all parts. In collaboration with the radiologists, this guide technique can be formulated into a revised chart for their own personal standards of radiographic quality.

On an average patient (mid-range for the average part thickness) select a part and make radiographs with: (1) the guide MAS, (2) one-half the suggested guide MAS, and (3) twice the suggested guide MAS. Take these radiographs to the radiologist and ask which one he prefers. If none are acceptable, find what change in density will satisfy him and take a fourth exposure. After the radiologist has decided on one particular radiograph for overall quality, the remainder of the chart can be adjusted.

This procedure involves the determination of a correction factor. It can be found by the following formula:

$$\text{correction factor} = \frac{\text{adjusted MAS}}{\text{guide MAS}}$$

461

Once the correction factor is computed, it can be applied to formulate the revised chart by multiplying each suggested guide MAS for each part by the correction factor. The new chart will give adequate penetration, consistent low contrast, and the desired density for any radiograph.

SUPERTECH

The newest and perhaps the most effective method of selecting technique factors involves the use of an optimum KVP exposure slide rule which is also usable with variable KVP technique. This slide rule method allows the technician to use up to two hundred combinations of KVP, MA, and time, all producting acceptable films.

Supertech also requires an accurate measurement of each part to be radiographed.

Chart A Part Thickness

After careful measuring of the part, through the path where the central ray will travel, the desired part is located on the front of the Supertech slide rule. The centimeter measurement is then set in the appropriate window. There is a black window for adult centimeter measurements and a red window for children under 12 years of age.

Chart B Correction Factors

As with all methods of technique selecting, there must always be a starting point. The starting point for the Supertech slide-rule is high speed screens, 12:1 grid, at 40" FFD unless otherwise noted on the chart.

All corrections appear to the right of Chart A, with a corresponding plus or minus number. All required correction factors are added up, and the total correction factor (T.C.F.) set on chart B.

Chart C Exposure Technique

The next step is to turn over Supertech without moving the two slides. Match up any horizontal line on Chart C to determine the KVP and MAS combination.

The recommended KVP is shown on Chart A in parenthesis but to change contrast, KVP must be changed according to directions on back of slide B. The new MAS combination is to the right of the new KVP.

470

As has been seen the method of selecting technique factors is a complex procedure. It requires you, the X-ray Specialist, to make important decisions which safeguard your patient and result in the highest quality radiographs which could be attained. Therefore, treat the selection of technique factors as a science to insure both high quality radiographs and minimal patient exposure to x-radiation. It is recommended that you use "Supertech" or technique chart based on "Supertech" in the absence of any prescribed chart on the job. Correct use of "Supertech" will give all the advantages of Optimum kVp and give consistently better quality of films than almost any other system now in use. In the case that a given chart is required in a specific clinic use that chart unless you receive permission to do otherwise.

ACADEMY OF HEALTH SCIENCES
MEDICINE AND SURGERY DIVISION
X-RAY BRANCH

*LP 38-520-016
018

Construction and Handling of X-Ray Film (4 hours)

COURSES PRESENTED TO: 313-91P10, X-Ray Specialist

PLACE: Classroom

REFERENCES:

TM 8-280
Selman, Joseph. The Fundamentals of X-Ray and Radium Physics. 5th ed. Springfield, Illinois: Charles C. Thomas, Publisher, 1972, pp 256-257.

STUDY ASSIGNMENT: Read TM 8-280, pp 7-10 through 7-20, para 7-16

STUDENT UNIFORM AND EQUIPMENT: TM 8-280, GR 38-520-001-B

TOOLS, EQUIPMENT, AND MATERIALS: None

PERSONNEL: One instructor, 91P2H/91P3H/91P4H

INSTRUCTIONAL AIDS: "The Inside Story," by Eastman Kodak Company (see Annex A); movie projector; screen; chalk, chalkboard, and eraser

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Lecture (film)

FIRST THROUGH FOURTH HOURS

I. INTRODUCTION (5 min)

A. Opening Statement: X-ray film is the one thing which carries from the very first of the X-ray procedure to the very end. It is the final result on the film from which the doctor interprets anatomical structures. X-ray film can be mishandled; it has certain properties which affect its exposure and methods of processing. These factors should be recognized by the specialist using the film.

B. Objectives

1. Name the material of which X-ray film base is made.

2. Name the materials of which X-ray film emulsion is made.

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*This lesson plan supersedes LP 38-520-016, 087.

464

3. Name the light sensitive material in X-ray film emulsion.
4. Describe the function of gelatin in the emulsion of the film.
5. Describe the function of silver bromide in the emulsion
6. Describe the process of converting the latent image to visible image.
7. Describe the correct method of holding film with one hand.
8. Describe the factors which contribute to film fog during storage.
9. Define latent image.

C. Class Procedure and Lesson Tie-in: None

II. EXPLANATION (170 min)

A. Film, "The Inside Story" (35 min)

1. Introduction
    a. "The Inside Story" (30 minutes)
    b. Major points
        (1) Materials used
        (2) Cleanliness
        (3) Handling of materials and film
2. Showing of film, "The Inside Story" by Kodak (30 min)
3. Discussion or questions

B. Construction of Film

NOTE: Students using GR 38-520-001-1B have major headings filled in and must complete their notes as per outline.

1. History of materials
    a. First film - sheet of glass (base) with emulsion - breakable (1895-1918, World War I)
    b. Cellulose nitrate (base) with emulsion - explosive (1918-1930)
    c. Cellulose acetate (base) with emulsion (1930-1965)

(1) Absorbed water

(2) Easily torn - plastic

d. Polyester - (base) with emulsion (1965 to present)

(1) Absorbs little water

(2) Hard to tear

(3) Thinner

2. Film base

a. Purpose - support and protection

b. Materials in composition (polyester base)

NOTE: Diagram flow chart on board. See Annex B.

(1) DMT - dimethyl terebthalate

(2) Ethylene glycol (also used in antifreeze)

QUESTION: Where do these two components originally come from?

ANSWER: Oil.

(3) Blue dye

3. Emulsion

a. Purpose - records the latent image

b. Materials in composition

NOTE: Diagram flowchart on board. See Annex B.

(1) Gelatin - holds silver bromide crystals

(2) Silver bromide crystals

(a) Light sensitive material (function)

(b) Interaction of light and X-ray photons put latent image on the film

C. Characteristics of Film

1. Latent image

a. Definition - the latent image is the invisible image on the film which needs to be chemically treated to make it visible.

b. Formation

(1) Photon ionizes AgBr crystal

(2) Electron migrates to sensitivity speck, making it negatively charged

(3) Sensitivity speck attracts interstitial silver ions

(4) When this process has occurred 3 - 8 times, the crystal has a latent image

2. Conversion of latent image to visible image

NOTE: Use radiographs

a. Development

(1) Exposed crystals

(a) Break silver bromide bond

(b) Removes bromide

(c) Turns silver$^+$ to black metallic silver

(2) Unexposed crystals - no effect

b. Fixing (hypo)

(1) Stops development process

(2) Removes all silver bromide from film

(3) Hardens emulsion

QUESTION: Is the fixer selective of only exposed or unexposed silver bromide crystals?

ANSWER: No. It will remove all silver bromide crystals remaining on film whether exposed or unexposed.

D. Packaging

1. Boxes: 25, 75, or 100

   2. Metal foil bag - reflect heat and stray radiation, or
   3. Plastic bag - keep out moisture
   4. Paper covering on individual films (occasionally)
   5. Individually packaged film (occasionally)

E. Factorswhich Contribute to Film Fog During Storage
   1. Heat - effects (depending on storage time and temperature, fog can be caused on film subjected to excesses)
   2. Pressure - exposes film
   3. Light leaks - seal cracks
   4. Fumes - chemical fog
   5. Lead-lined darkroom - X-ray exposure

F. Storage, Use, and Handling
   1. Store upright
   2. Refrigeration - remove 12 to 36 hours before use
   3. Use before expiration date or it could be fogged
   4. Load holders - (with one hand) hold film vertically by corner hanging downward
   5. Static electricity - cool, dry weather

G. Questions from Students

III. SUMMARY (5 min)

A. Review of Main Points
   1. Construction
      a. Base
      b. Emulsion
   2. Characteristics
      a. Latent image

b. Visible image

3. Packaging

4. Storage

5. Darkroom protection

6. Handling precautions

B. Closing Statement: An understanding of how film is made, how it is exposed, and the basic changes that occur during processing is essential for efficient operation of the darkroom in the clinic. The film is protected beforehand by packaging and the correct type of storage procedures. Fog can be one of the greatest enemies to quality film; and as technicians, we need to observe certain precautions to avoid damaging the film.

ANNEX A
INSTRUCTIONAL AID

Film

"The Inside Story," by Eastman Kodak Company

Movie shows construction of X-ray film, including materials used and manufacturing procedure. Methods of storing and handling the film, as well testing the film for its properties, are included.

NOTE: Movie to be shown at the beginning of class.

ANNEX B
INSTRUCTIONAL AID

Flowchart

The flowchart shows the manner and sequence in which X-ray film is created and constructed.

NOTE: Flowchart to be used at IB2(1) to describe order of film construction

NOTE: PAGES 469 - 470 HAVE BEEN DELETED HOWEVER ALL MATERIAL HAS BEEN INCLUDED.

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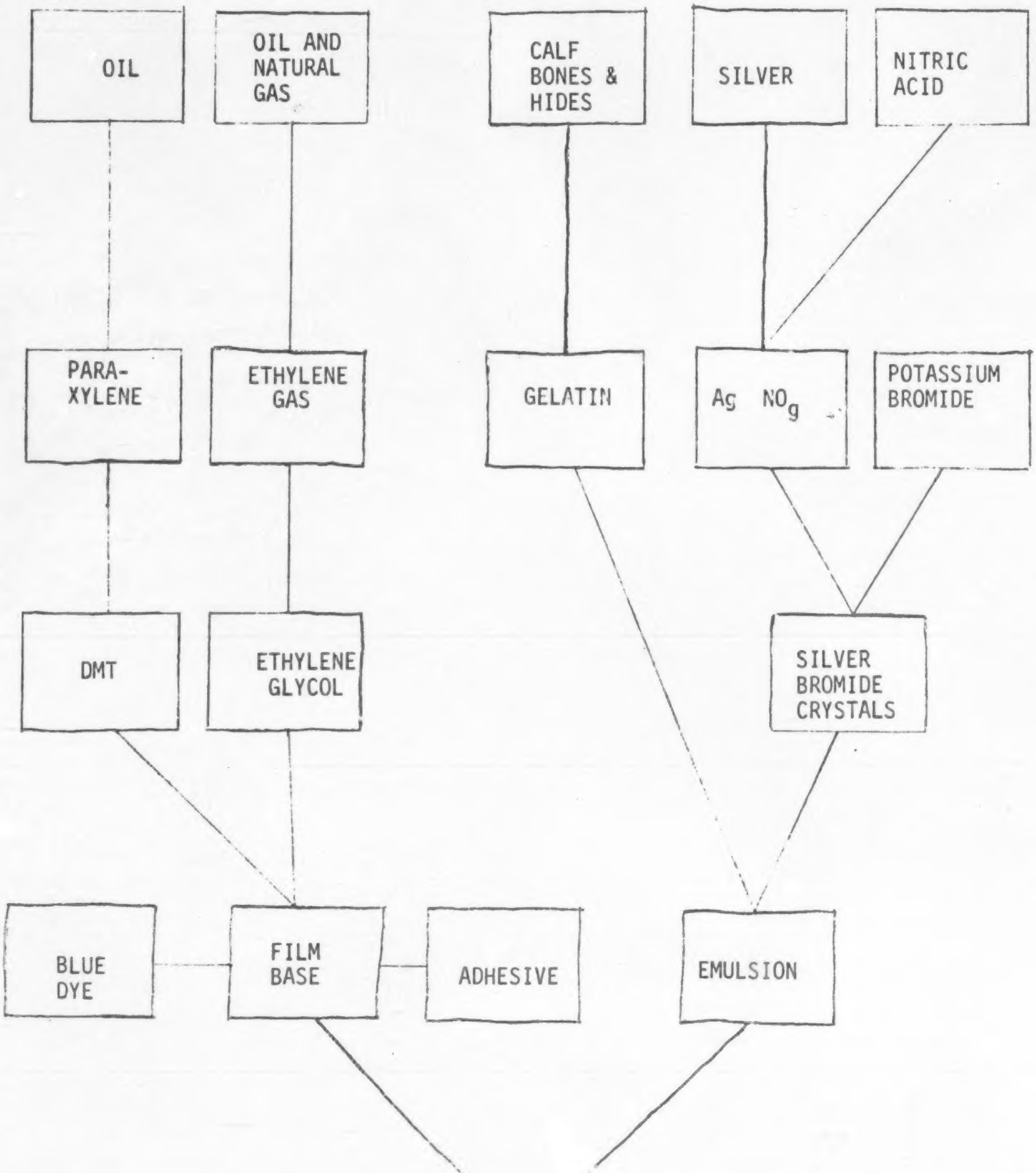
OIL
OIL AND NATURAL GAS
CALF BONES & HIDES
SILVER
NITRIC ACID
PARA-XYLENE
ETHYLENE GAS
GELATIN
Ag NO_g
POTASSIUM BROMIDE
DMT
ETHYLENE GLYCOL
SILVER BROMIDE CRYSTALS
BLUE DYE
FILM BASE
ADHESIVE
EMULSION
FILM

ACADEMY OF HEALTH SCIENCES
MEDICINE AND SURGERY DIVISION
X-RAY BRANCH

*IM 38-520-016
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Construction and Handling of X-Ray Film

The one thing that carries through from the beginning of the work in the X-ray clinic to the very end is the X-ray film. It is the results on the film for which we work and so the consideration of the X-ray film is very important. This period we are going to study the basic parts of the X-ray film and their relationship to each other.

This information is important to help you understand the theory of film exposure, sensitization, and processing. Only as you understand these features of the X-ray film will you be able to avoid artifacts which are so easily produced.

A quick review of the materials formerly used in making film shown many advantageous improvements. The first plates were made of a glass base with an emulsion coating. The major problem with this film was the breakage hazard. Also, the glass base was very thick so the quality of the final product was lacking in detail. To improve this film, a film with a thinner base as well as being tougher was found. The next base used was made of cotton mixed with nitric acid. The danger here was that this reaction caused a very volatile mixture and explosions were noted quite often.

Immediate changes had to be made so acetic acid was substituted for nitric acid and the volatile nature of the reactants disappeared. What they had produced was cellulose acetate. This base was stronger than glass, but still could be torn and was much thinner. Another problem arose however, from the fact that this "plastic" base would absorb water.

A recent chemical development has changed the industry again. Now, a polyester is used. This base is stronger and very difficult to tear, thinner producing better detail, and will not absorb as much water.

The X-ray film is in two parts--film base and emulsion. The film base is the tough rigid portion of the film which is used to support the emulsion. Were it not for the film base, the emulsion would be too fragile and would be easily damaged.

The polyester base is made by "cracking" crude oil forming the substance parazylene. When this substance is mixed with methyl alcohol and other chemicals, a product of dimethyl-terebthalate (DMT) is formed. This DMT is one-half of the final preparation. Ethylene glycol is the other major ingredient. This is commonly called antifreeze. It is produced from oil and natural gas in a process of oxidizing and hydrolizing ethylene gas. When DMT and ethylene glycol are mixed in heat for a long period of time, a polyester is formed. The polyester is reheated and given a two-way stretch until its thickness is .007 inch.

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*This instructor's manuscript supersedes IM 38-520-013, 022.

IM 38-520-016
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The X-ray film base was made of cellulose acetate prior to polyester. This is made by reacting cotton, which is chemically termed cellulose, with acetic acid. The resulting material, cellulose acetate, is dissolved in a solvent to give a very viscous, syrup thick fluid. The base of almost all film was made of cellulose acetate, but X-ray film has a blue dye added to give it a characteristic blue color. The purpose of this blue dye is to reduce the glare of white light that shines through the film during viewing. This white light glare greatly impairs the viewing of films when one must look at them for prolonged periods of time.

The emulsion of the X-ray film is the portion which, in the unprocessed film, contains the X-ray sensitive crystals and which, in the processed film, contains the image. The emulsion consists of a gelatin and silver bromide crystals which are sensitive to the action of the X-rays. The gelatin, because it can absorb large quantities of water, allows the processing chemicals to get into the emulsion and react with the silver bromide crystals.

To make the silver bromide, silver is first reacted with nitric acid to form silver nitrate. The silver nitrate is then mixed with potassium bromide. Silver bromide is made and potassium nitrate becomes a byproduct. The silver bromide, potassium bromide reaction, actually occurs in a solution of gelatin so the insoluble silver bromide is suspended in an emulsion and does not settle out.

When the emulsion is coated on the film base, X-ray film is produced. X-ray film differs from photographic film in two ways. The film base is a characteristic blue color and X-ray film has an emulsion on both sides of the film base while photographic film is a single emulsion film.

When a film has been exposed, the silver bromide crystals in the emulsion contain an invisible image called the latent image.

The X-ray film which has been exposed has many areas on the film which vary in the degree of sensitization of the silver bromide crystals. These different areas of sensitization represent different anatomical details and are made visible by the processing solutions.

In the darkroom, these areas of sensitization--that is, the latent image--must be brought out or rendered visible by a process known as development. In general, the development is the process of changing the exposed silver bromide crystals to black metallic silver. The areas that are heavily exposed will show up quite dark, while areas of lighter exposure will have fewer silver deposits and will appear much lighter.

Since the unexposed silver bromide crystals are unaffected by the developer solution, they must be removed before light can readily pass through the film and show the image to the best advantage. The process of removing the silver bromide is called clearing, and occurs in a second processing solution called the "hypo" or "fixer." The emulsion is also hardened to resist scratching by the action of the fixer.

We will now see a movie entitled "The Inside Story," which shows how X-ray film is constructed. You will also see how the developer and fixer chemicals are mixed, canned, and shipped out. Although this is a commercial film, you will enjoy seeing the manufacturing processes which occur in the manufacture of X-ray film and you will be able to understand better why X-ray film is so sensitive to mishandling.

An understanding of how film is made, how it is exposed, and the basic changes that occur during processing is essential for efficient operation of the darkroom.

X-ray film is very sensitive to mishandling. To make you aware of the sensitivity of the film, we are going to spend this hour showing you some of the many ways in which mishandling can ruin film. By making you aware of what you should not do, you will learn how to handle X-ray film to avoid ruining it.

As you saw in the movie, when the X-ray film is packaged, it is handled very carefully. The films are boxed in lots of 25, 75, or 100. The Army usually gets the large boxes of films. The films are first placed between a sheet of protective paper, then stacked between protective cardboards, and then sealed in an airtight metal foil-coated plastic bag. The plastic keeps out moisture and the foil reflects heat, thus protecting the film from heat fog to some degree. The foil-plastic bag is then placed in a cardboard box which is sealed with tape and then into a corrugated cardboard box. When we receive large quantities of film, many of these boxes will be crated into large wooden boxes.

The temperature at which film is stored determines how long the film may be stored until used. If, for example, the film is stored at temperatures of 90° to 110° F., we must consider that the film is fogged beyond usefulness after a 2-week period. At lower temperatures, the film may be stored for longer periods. At 75° F., films may be considered good for 2 months. At 60° F., for 6 months, and at 50° F., for as long as a year. If it is available, a refrigeration box should be used to store the films so the fogging effect of heat is minimized.

Naturally, X-rays will affect the film. Any area in which films are stored must be protected from X-rays. The darkroom and storage areas should be lead-lined. Usually the film bins are also lead-lined.

Certain types of chemical fumes will cause the emulsion of the film to become fogged. Vapors from acids such as hydrochloric, nitric, etc., common household ammonia water, illuminating gas, sewage gases, and so on, will cause the film to have an unwanted veil of fog.

Silver bromide crystals are not only sensitive to the action of light and X-rays, but to any form of energy which may be imparted to the crystals. Bending or rolling the film will cause the areas which have been most distorted to show up as areas of greater density after processing. It is neccessary to keep any type of pressure off the film. Film boxes when stored, should be placed side by side on the long edge and not one on top of the other. When handling a film, care should be taken that the film is not bent. In handling a film horizontally, both hands must be used or the film will bend causing portions to be exposed. When holding a film with one hand by the corner, the film should be allowed to hang vertically for the same reason.

All boxes of film have an expiration date and all film should be used before this date. If films are improperly stored, the film may well be ruined before this expiration date, but when stored under ideal conditions of temperature and away from radiation, the film may be considered good until the expiration date. When new stocks of film come in, the old stocks should be used first, otherwise the old gets older while the new is being used.

When films are stored in cool conditions during hot weather, a danger exists if the film box is opened immediately after removal from the refrigerator. This is especially true when the weather is hot and humid. A cool film opened to the humid air will cause moisture to condense on the film, swelling the emulsion, which may stick to the paper on the film. To avoid this, film boxes should be removed from the refrigerator from 12 to 36 hours before they are opened. This allows the film to come up to room temperatures so it will not "sweat."

Since the film is sensitive to the action of light, care must be taken to assure that there are no holes allowing light to enter the darkroom. The cassettes must also be in good condition to prevent light leaks around the edges. The bins in which film are stored should be closed at any time the lights are on. If by accident a film bin is left open when the lights are turned on, the film must be considered to be ruined and should no longer be used.

During the winter months when the weather is cool and dry, static electricity is a constant threat. Any time two dissimilar substances are rubbed together, a static electrical charge is generated. In cool dry weather, this is much more pronounced than usual. As the static electricity discharges, small sparks will occur at the emulsion of a charged film. These discharges cause small exposed areas in the form of dark streaks, "Christmas trees," or "stars." To avoid static electricity marks, the film should be handled carefully avoiding contact with other surfaces. Fast movement increases static discharges.

In loading the cassette or cardboard holder, care should be taken to hold the film vertically with one hand and when held horizontally, to use both hands. The cardboard holder must be loaded with the large flap innermost to avoid light leaks and undue rubbing of the film against the intensifying screens of casettes should be avoided to prevent static electrical discharges.

An understanding of how film is made, how it is exposed, and the basic changes that occur during processing is essential for efficient operation of the darkroom in the clinic. The film is protected beforehand by packaging and the correct type of storage procedures. Fog can be one of the greatest enemies to quality film; and as technicians, we need to observe certain precautions to avoid damaging the film.

ACADEMY OF HEALTH SCIENCES
MEDICINE AND SURGERY DIVISION
X-RAY BRANCH

*LP 38-520-017
028

Film Holders and Hangers (3 hours)

COURSES PRESENTED TO: 313-91P10, X-Ray Specialist Course

PLACE: Classroom

REFERENCES:

TM 8-280
Selman, Joseph. The Fundamentals of X-Ray and Radium Physics. 5th ed. Springfield, Illinois: Charles C. Thomas, Publisher, 1972, 256-268.

STUDY ASSIGNMENT: Before class, study TM 8-280, pp 6-38 through 6-42, pp 7-9 through 7-10.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280

TOOLS, EQUIPMENT, AND MATERIALS: None

PERSONNEL: One instructor, 91P2H/91P3H/91P4H

INSTRUCTIONAL AIDS: Demonstration cassettes; wire screen; intensifying screens; cardboard holders; film hangers; chalk, chalkboard, and eraser.

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Lecture

FIRST AND SECOND HOURS

I. INTRODUCTION (5 min)

A. Opening Statement: There are two types of film holders - cardboard holders and cassettes. Each type has its advantages and disadvantages, and each type requires a different type of exposure. You will need to know the relationship which exists between cassette and cardboard holder exposures whenever it is necessary to change from one to the other.

B. Objectives

1. Identify the two types of film holders.

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*This lesson plan supersedes LP 38-520-012, 032.

2. Select the three most common sizes of film holders in use in Army X-ray clinics.

3. Given either a cardboard or cassette film holder:

   a. Match the appropriate theory of exposure with the corresponding film holder.

   b. Identify the components of each type from cross sectional drawings.

   c. List the advantages and disadvantages of each type of film holder.

4. Given an intensifying screen:

   a. Identify the flouresing crystals which are used in intensifying screen construction.

   b. Match intensifying screen crystal size with each of the following factors:

      (1) Speed of screens

      (2) Detail produced on the film

      (3) Contrast produced on the film

   c. List the steps to properly wet or dry-clean screens.

5. Identify the three sizes of film hangers.

C. Class Procedure and Lesson Tie-in: None

II. EXPLANATION (70 min)

NOTE: Refer students to GR 38-520-001-1B, page 50, see Annex A.

A. Purpose of Film Holder

   1. Light tight

   2. Rigid

   3. Radiolucent

B. Sizes

C. Types of Film Holders

   1. Cardboard holder

QUESTION: What is a cardboard holder?

ANSWER: A cardboard holder is an X-ray film holder composed of a light tight paper envelope with heavy cardboard support on either side.

- a. Theory of exposure
- b. Construction
- c. Procedure for loading

QUESTION: How do you load a cardboard holder?

ANSWER: Place film in, fold the large flap down, next the side flaps, and lastly the end flap.

- d. Advantages vs disadvantages
  - (1) Advantages
    - (a) More
    - (b) Cheap
    - (c) Lightweight
    - (d) More patient comfort
  - (2) Disadvantages
    - (a) Requires high mAs
    - (b) Not recommended over 10 cm
    - (c) Not as durable

2. Cassette
   - a. Theory of exposure
   - b. Construction
   - c. Advantages vs disadvantages
     - (1) Advantages
       - (a) More durable
       - (b) Easily cleaned
       - (c) Less patient exposure

(d) Used for all body areas

(2) Disadvantages

(a) Cost

(b) Less detail

(c) Heavy

D. Intensifying Screens

1. Construction

a. Cardboard or plastic support

b. Adhesive

c. Active layer

QUESTION: What is the crystal in the intensifying screen made of?

ANSWER: A type of phosphorus material which lights up when struck by X-rays.

(1) Calcium tungstate or barium lead sulfate

(2) Characteristics of a good crystal

(a) Fluoresce blue-violet light - expose film

(b) Respond well to diagnostic K.V.

(c) Will not deteriorate appreciably with use or age

(d) Does not have significant after glow or lag

(e) Can be used to manufacture screens of uniform quality

d. Protective coating

2. Crystal size

a. Light produced

b. Speed of screen 487

c. Effect on detail

d. Effect on contrast

3. Screen film contact test - check for warping of screens or film holder

    a. Poor contact - blurred image

NOTE: Approximately as little as .005 inches space between film and screen will cause poor film detail.

    b. Wire screen

    c. 50 kVp, 1.5 to 5 mAs, 40" FFD

    d. Correction

E. Cleaning Screens

1. Dry cleaning - dust

QUESTION: Why is dry cleaning utilized in screen care?

ANSWER: Keep screen clean without taking them out of service.

    a. Leave screens in cassette

    b. Use camel's hairbrush or a lint-free dry rag

NOTE: Do not rub screens; just dust gently!

2. Wet cleaning

QUESTION: Why is wet cleaning utilized in screen care?

ANSWER: To remove stains from screens.

    a. Purpose - to remove stains, fingerprints, or smudges

    b. Mild soap and water

        (1) Soapy cloth wrung dry

        (2) Use moderate pressure

        (3) Remove soap (damp cloth)

NOTE: Use water sparingly to avoid warping cardboard backing of screen. Allow screens to completely dry before replacing them in the cassette.

    c. Ethyl alcohol (grain alcohol 95 percent)

        (1) Dampen cloth

(2) Remove stain (use little pressure)

(3) Allow to dry

d. Manufacturer's solution

NOTE: The protective coating of some manufacturer's screens may be dissolved by alcohol. Refer to manufacturer's cleaning instructions for each type of screen.

NOTE: Manufacturer's solution is the best choice for wet cleaning.

F. Questions from Students

III. SUMMARY (2 min)

A. Review of Main Points

1. Advantage and disadvantage of cardboard
2. Advantage and disadvantage of cassette
3. Screen characteristics
4. Stress using little liquid in cleaning
5. Periodic dry cleaning

B. Closing Statement: Any dust or dirt which is in the cassette will keep light from reaching the film. This impairs radiographic quality. Cleaning screens periodically is important to maintain good radiographic quality.

THIRD HOUR

II. EXPLANATION/DEMONSTRATION (40 min)

A. Hanger Sizes

1. 8 x 10 inches
2. 10 x 12 inches
3. 14 x 17 inches

489

B. Structure - stainless steel

1. Frame
2. Stationary clips

3. Spring clips

C. Hanging Film

QUESTION: Which clips should be used first when hanging X-ray film for manual processing?

ANSWER: The stationary clips at the bottom are the ones to use first.

NOTE: Demonstrate - during this demonstration, each student should have one hanger and a film and should follow each step with the instructor.

D. Practical Exercise

NOTE: Each student should hang and unhang film until he can do it with his eyes closed.

E. Unhanging Film - Demonstrate

QUESTION: How do you unhang films?

ANSWER: By undoing the spring clips, one at a time while holding the hanger vertically, then releasing the stationary clips.

NOTE: Read TM 8-280, pp 153-157.

F. Questions from Students

III. SUMMARY (5 min)

A. Review of Main Points

1. Prevent bends in film ("kiss")

2. Hang bottom first

3. Handle film and hanger together

B. Closing Statement: Film improperly hung may be bent in the hangers and touch or "kiss" in the processing solutions or dryers. Complete destruction of the films may result in processing if hanging of the films is improperly performed.

ANNEX A

Film Holders and Hangers

OBJECTIVES:

1. Identify the two types of film holders.

2. Select the three most common sizes of film holders in use in Army X-Ray clinics.

3. Given either a cardboard or cassette film holder:

    a. Match the appropriate theory of exposure with the corresponding film holder.

    b. Identify the components of each type from cross sectional drawings.

    c. List the advantages and disadvantages of each type of film holder.

4. Given an intensifying screen:

    a. Identify the flouresing crystals which are used in intensifying screen construction.

    b. Match intensifying screen crystal size with each of the following factors:

        (1) Speed of screens

        (2) Detail produced on the film

        (3) Contrast produced on the film

    c. List the steps to properly wet or dry-clean screens.

5. Identify the three sizes of film hangers.

A. Purpose of a Film Holder

1. Light tight

2. Rigid

3. Radiolucent

B. Sizes of Film Holders

1. 8 x 10 inches

2. 10 x 12 inches

3. 14 x 17 inches

4. Others

C. Types of Film Holders

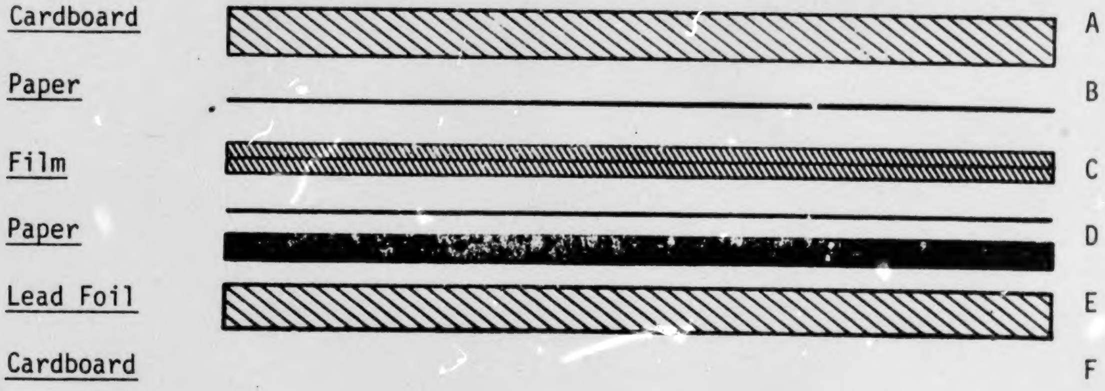
1. Cardboard

   a. Theory of exposure

      (1) Direct exposure by X-rays

      (2) Best used on extremities

   b. Construction


Cardboard
Paper
Film
Paper
Lead Foil
Cardboard
A
B
C
D
E
F

   c. Procedure for loading

      (1) Place film in paper

      (2) Fold

         (a) Tongue

         (b) Side

         (c) Side

         (d) Bottom

      (3) Close cardboard

   d. Advantages versus disadvantages

      (1) Advantages

         (a) More detail

486

- (b) Cheap
- (c) Lightweight
- (d) More patient comfort

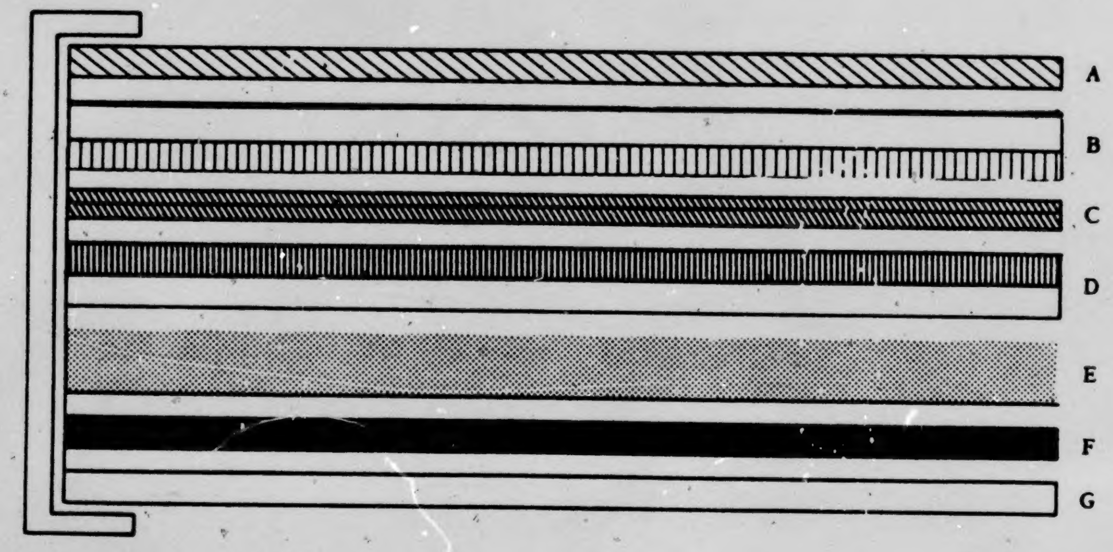
(2) Disadvantages

- (a) Requires high mAs
- (b) Not recommended over 10 cm
- (c) Not as durable

2. Cassette

a. Theory of exposure - 95% light-indirect exposure

b. Construction



NOTE: Held closed with compression bars.

c. Advantages versus disadvantages

(1) Advantages

- (a) More durable
- (b) Easily cleaned

493

- (c) Less patient exposure
- (d) Used for all body areas

(2) Disadvantages

- (a) Cost
- (b) Less detail
- (c) Heavy

D. Intensifying Screens

1. Construction

    a. Cardboard or plastic support

    b. Adhesive

    c. Active layer (crystals)

        (1) Barium lead sulfate

        (2) Calcium tungstate (most common in use)

        (3) Rare earth phospors (new)

    d. Protective coating

2. Crystal size

    a. Bluish-violet light

    b. Has high, par, or low speed

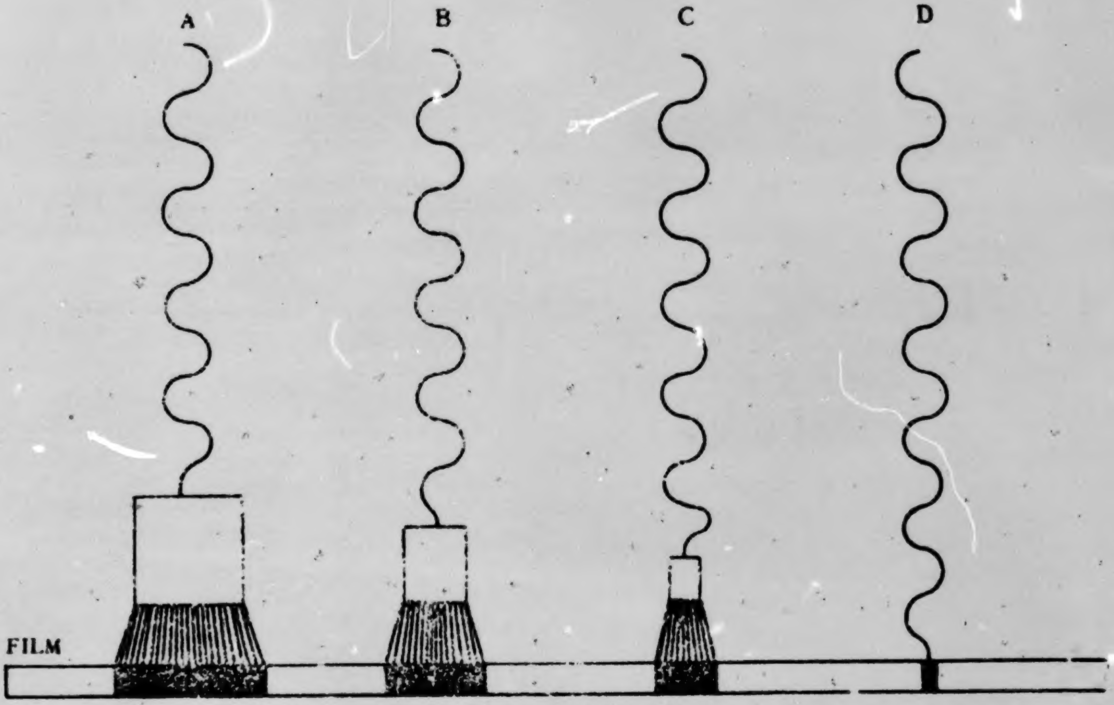
    c. Activated only by high energy photons

    d. Respond to entire kV range

    e. Deteriorate very slowly

    f. Short lag or afterglow

Crystal Size	Speed	Detail	Contrast
Large	High	Poor	High
Medium	Par	Average	Average
Small	Slow	Good	Low
Direct Exposure	Cardboard	Best	Lowest

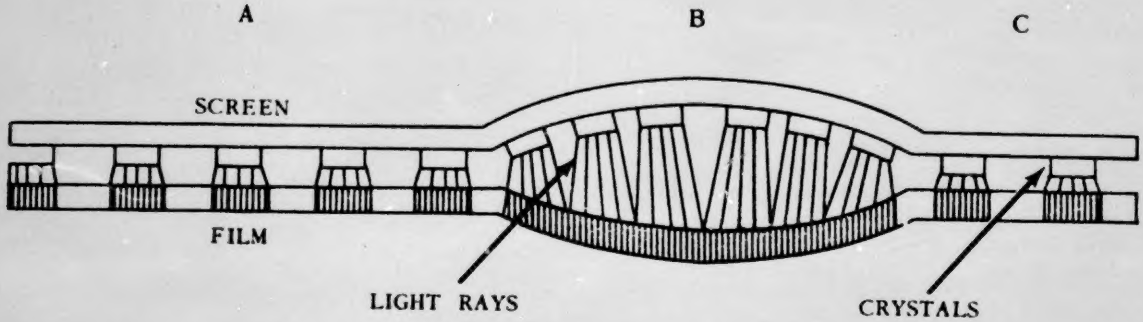


Effect of crystal size on speed of intensifying screen and on detail of roentgenographic image. A, large crystal size - more light is produced by the crystal and a high-speed results. B, medium sized crystals - a medium amount of light is emitted, and a medium or par-speed screen results. C, small crystals - less light is emitted, and a slow-speed but high-definition screen results. D, direct action of X-rays - no crystals are used, and only X-rays expose the him. There is a drastic reduction in speed, but definition is greatly improved.

3. Film screen contact test

   a. Purpose - to check for warped screens which result in poor detail

   b. Procedure - wire mesh or paper clips radiographed at 50 kVp, 1.5 to 5 mAs, 40" FFD. Radiograph processed and viewed for changes in detail and contrast.



Poor screen contact produces a blurred roentgenographic image. In areas A and C, the film and screen are in good contact—good detail results. In area B light rays from one crystal cross those of others, and the resultant image of each crystal blurs into those of the adjacent crystals.

F. Cleaning Screens

1. Dry cleaning - dusting and removing dirt

   a. Leave screens in cassette

   b. Dust gently with

      (1) Camel's hairbrush

      (2) Lint-free rag

   c. Purpose - removes dirt and dust

2. Wet cleaning

   a. Purpose - remove stains, fingerprints, and smudges

   b. Three methods

      (1) Ethyl or wood alcohol

         (a) dampen cloth

         (b) Rub screen with moderate pressure

        (c) Allow to dry by evaporation

    (2) Mild Soap and water

        (a) Soapy cloth, wrung dry

        (b) Rub screen using moderate pressure

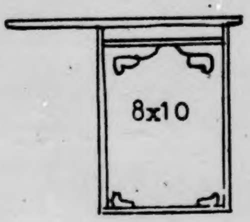
        (c) Remove soap with a damp cloth

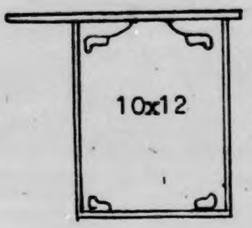
        (d) Leave screens on edge overnight to dry

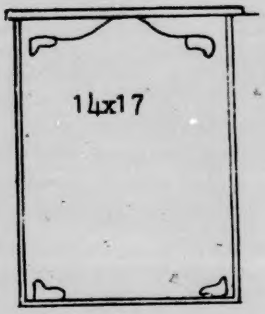
    (3) Manufacturer's solution

G. Film hanger: Purpose - manual processing

NOTE: Always hang bottom clips first, holding hanger upside down







491

ACADEMY OF HEALTH SCIENCES
MEDICINE AND SURGERY DIVISION
X-RAY BRANCH

*IM 38-520-017
028

Film Holders and Hangers

There are two types of film holders - cardboard holders and cassettes. Each type has its advantages and disadvantages, and each type requires a different type of exposure. You will need to know the relationship which exists between cassette and cardboard holder exposures whenever it is necessary to change from one to the other.

Since X-ray film is sensitive, not only to X-rays but also to visible light, it is essential that the film be held in some sort of device which will allow the X-rays to pass through, but which will exclude the fog-producing light.

The most common sizes of film holders found in the clinic today are 8 x 10, 10 x 12, and 14 x 17 inches.

We have two types of holders for our X-ray film which are used for this purpose. We are going to study the theory of exposure and structure of these holders so you will understand the differences and know characteristic effects of each type of the final film.

The cardboard holder is the simpler of the two types of film holders. The cardboard holder excludes the light, but allows the X-rays to pass through the film. The direct action of the X-rays sensitizes the silver bromide crystals in the emulsion of the film. Note here, that the X-rays themselves expose the film.

The cardboard holder consists of a light tight paper envelope with a heavy cardboard support on either side.

The purpose of the cardboard is to prevent bending of the X-ray film which would cause pressure marks on the final film. A thin sheet of lead is placed at the back of the holder to prevent the X-rays from passing through to the table where secondary rays would be formed, many of which would scatter back to the film, fogging it.

In loading the cardboard holder, the large flap of the paper envelope should be folded first, then the side flaps and the end flap. If the X-ray film comes from the manufacturer with paper separating the sheets of film, the paper should be left on the film when loading the cardboard holder. The paper affords a larger margin of protection against the light. The film in the cardboard holder is exposed by the direct action of X-rays on the film.

The cardboard holder has one big advantage aside from its cheaper cost. Since the direct action of the X-rays exposes the film, the detail is very fine. Along with this fine detail, however, comes the big disadvantage of cardboard holders. They require approximately 10 times the exposure that a

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*This instructor's manuscript supersedes IM 38-520-012, 032.

cassette would use for the same part. This means that the patient is exposed to much more radiation than would otherwise be necessary. Because of the need for even higher exposures, cardboard holders should not be used for parts whose thickness is greater than 10 cm.

The cassette is based on a different principle of exposure from the cardboard holder. Where the film in a cardboard holder is exposed by the direct action of X-rays, the film in a cassette is mainly exposed by visible light which comes from adjacent fluorescent screens. These screens, called intensifying screens, have a fluorescent material coated on them which will emit light in the areas which are exposed to X-rays. This screen, being next to the film, will cause the film to be exposed in the corresponding areas due to the light emitted from the screen. Approximately 95 percent of the density on the film is caused by fluorescence while about 5 percent is due to the direct action of the X-rays.

The cassette is a strong rigid holder. The cassette is held together by a frame which may be either stainless steel or aluminum. The front of the cassette is made of a sheet of bakelite plastic so the X-rays can easily penetrate it. Next to the bakelite is the front intensifying screen with the sensitive crystals toward the film which is, in turn, placed next to the back intensifying screen's fluorescent crystals. The back screen is attached to a felt backing which has two functions. The felt, being soft and spongy, presses the screens and film into close contact with each other; this is necessary to produce good detail on the film. Secondly, the edges of the felt fit into the crack between the cassette frame and the back. This seals the cassette against the action of light which would otherwise reach the film to expose it around the edges. Behind the felt, a thin sheet of lead is used to absorb the backscatter radiation just as it is in the cardboard holder. A stainless steel or aluminum back, hinged on one end and held in place by locking clip springs, completes the construction of the cassette.

The only radiographic disadvantage of the cassette is that the detail which is produced is somewhat less than when using a cardboard holder. The cassette's main advantage lies in the fact that the exposure time may be greatly reduced with a corresponding decrease in motion and radiation to the patient.

Intensifying screens are made using a very special type of cardboard or plastic as a base. These materials must be chemically inert so it will not react with the fluorescent crystals, and it must be uniform with no lumps which would cause inhomogeneous absorption of X-rays in the screen. The fluorescent crystals may be of several types of phosphor materials. Calcium tungstate crystals have proven to be the best, and this material is most widely used. Barium lead sulfate is another crystal material which is used. The newest type of crystal used is called a "rare earth phosphor." It permits even faster exposure times than the standard intensifying screen. The crystals are chosen because they possess the following characteristics. They must fluoresce a blue-violet light to which the film is especially sensitive. Their activity must respond to the diagnostic kV range. Their capability to continuously emit light should not decrease with usage and age. They should light up only when activated and should decrease their glow quickly after activation ceases. This is referred to as "screen lag" and it should be at a minimum. Finally, the type of crystal used should produce screens of uniform quality. A protective coating of clear plastic keeps the fluorescent crystals from being rubbed off the screen.

The size of the calcium tungstate crystals is an important consideration. Screens come in three main types depending on the amount of light that is produced with a given amount of X-rays. This affects what is known as the speed of the screens. A screen which gives out a greater amount of light could use a shorter exposure time and would be called a fast speed or high speed screen.

Conversely, a screen which emits a lesser amount of light for a given exposure is a slow speed screen. The amount of light given out is dependent upon the crystal size of the screen. Large crystals produce a fast speed, medium sized crystals a medium speed, and small crystals a slow speed. A corresponding effect is produced on detail and contrast. Larger crystals cause a greater dispersion of light, producing poorer detail while the smaller crystals give out light over a smaller area producing a better detail. Large crystals will cause a greater contrast and smaller crystals a lower contrast. Thus, screens with large crystals produce fast screens with poorer detail and higher contrast. Medium speed screens use medium sized crystals, produce medium detail, and moderat scale of contrast. Small crystals produce high definition, slow speed, and a low contrast. It would be desirable to have the fastest possible screen with the best possible detail, but it is impossible to have both. We either have fast screens with poor detail, slow screens with good detail, or we have to make a compromise. This is what is usually done. The Army uses medium speed screens to produce medium detail as a compromise between the speed and detail.

A basic understanding of the action of intensifying screens is essential in their care and use. Intensifying screens are the heart of the cassette. Next period we will discuss the care of intensifying screens.

Poor screen film contact results in a blurred image. To determine the area of poor contact and correct the difficulty, the following test is made. Lay a wire screen on top of the loaded cassette, make an exposure through it of medium density; an exposure of 50 kVp and 5 mAs at a 40-inch distance will give an average desired density. The blurred area is noted on the film and the poor contact area is located in the cassette and corrected by the manufacturer's recommended procedure. When corrections cannot be made, the cassette must be replaced as unserviceable.

Intensifying screens are quite sensitive to mishandling. This period, you will learn how to care for intensifying screens in daily handling and cleaning. When you get in the clinic, you will find that cassettes are used much more often than they are here at the Academy. They may enter and exit the darkroom dozens of times a day. All of this handling requires that the screens be cleaned periodically; and you, of course, may be called upon to do this cleaning.

There are two types of cleaning which may be performed on cassettes. Dry cleaning is performed to remove dust and dirt from the screens. During dry cleaning, the screens are left in the cassette and a camel's hairbrush or wad of cotton is used to wipe dust from the surface of the screens. The camel's hairbrush is preferred if available, since it can have a static electric charge placed on it, and this charge attracts the dust, making it easier to remove.

Wet cleaning is used to remove stains which have occurred on the surface of the screens. In wet cleaning, the screens should be removed and a soapy water solution or ethyl alcohol should be used, depending on the instructions from the manufacturer. In cleaning with soap and water, a mild soap should be used with clean, lint-free cotton cloths. One cloth with soap in it should be wrung out as dry as possible. Using moderate pressure, the stains should be rubbed until they disappear. The soapy residue should be removed with another damp cloth (clean water). Several rinses with the cloth should be made to insure complete removal of the soap. In using soap and water, caution must be taken to use as little water as possible. Excessive water will be absorbed by the cardboard backing of the screen, causing the screens to warp and produce poor film to screen contact. The screens must be left standing open on edge to allow complete drying, preferably overnight.

Cleaning with ethyl alcohol is recommended by some manufacturers of X-ray screens; but if it is not recommended, alcohol should not be used and the screens should be washed with soap and water as we have already discussed. In cleaning with alcohol, the cloth should not be too damp. Moderate rubbing should remove the stain. The film should be allowed to dry completely. The alcohol that should be used should be ethyl or grain only and should be 95 to 100 percent pure. Lower concentrations of alcohol clean less readily and also have too much water which tends to warp the cardboard base. The screen should then be allowed to dry for several hours before replacing in the cassette and loaded with film. The best way to wet clean the screens is to use the solution provided by the manufacturer and follow the instructions provided with the solution.

Any dust or dirt which may be in the cassette will keep light from reaching the film. Thus, light density areas occur which impair the radiographic quality. Cleaning screen periodically is important to maintain good radiographic quality.

In processing photographic film, the tray method is employed in which a flat tray is used to develop a few films at a time. In X-ray work, the quantity of films which are processed makes this slow method impractical. Processing of X-ray film is performed in deep tanks which can hold from 5 to 20 gallons of solution and into which the films are vertically suspended on film hangers. This period we are going to learn how films are hung in these hangers and actually practice hanging them. When you get to the darkroom, you will be unable to see how much of what you are doing, so we are giving you the chance to learn to hang films in the light.

Film hangers are made in the same sizes as the X-ray films; that is, 8 x 10, 10 x 12, and 14 x 17 inches. Naturally, the film hanger has to be slightly larger than the film it supports. The processing tank must also be large enough to allow the whole film in the hanger to be completely immersed in the processing solutions. Notice that all three sizes of film hangers have the same width at the top. This is necessary to suspend the hanger from the top of the tank.

The film hanger consists of a stainless steel frame slightly larger than the film and to which four clips are attached for attachment of the film to the hanger. The bottom of the film hanger is the portion which is at the bottom during processing, and the clips which are attached to the bottom are rigid and called stationary clips. At the top are clips attached to springs which are called spring clips.

In hanging the film, the stationary clips at the bottom are attached first and then the hanger is inverted and the spring clips are used to pull the film taut to prevent buckling and touching of the films in the tanks.

Issue all the students a piece of scrap film and a hanger. Have them follow you in every step while you show them how to hang a film. Learn to handle the film and hanger with one hand so you can operate the clips with the other. You will not have a lap to rest the hangers on when you stand up, so do not use it now.

Unhanging film can be done a right way or a wrong way. Do not tear the film from the hangers. By holding the holder vertically and releasing the clips on the top of either side while pushing the film off the clips, the film will easily be released from the hanger. A similar step with the bottom clips will complete the unhanging process. Practice this hanging and unhanging of film until you can hang them with your eyes closed.

Films which are improperly hung may buckle in the hangers and touch or "kiss" in the processing solutions or dryer. Complete destruction of films may result in processing if hanging of the films is performed improperly.

ACADEMY OF HEALTH SCIENCES
MEDICINE AND SURGERY DIVISION
X-RAY BRANCH

*LP 38-520-018
018

Darkroom Construction (1 hour)

COURSES PRESENTED TO: 313-91P10, X-Ray Specialist

PLACE: Classroom

REFERENCES:

TM 8-280.
Selman, Joseph. The Fundamentals of X-Ray and Radium Physics. 5th ed. Springfield, Illinois: Charles C. Thomas, Publisher, 1972, pages 270-274.

STUDY ASSIGNMENT: Before class, read TM 8-280, pp 7-1 through 7-9, para 7-1 through 7-9.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 and GR 38-520-001 B.

TOOLS, EQUIPMENT, AND MATERIALS: None

PERSONNEL: One instructor (X-Ray Branch), 91P2H, 91P4H

INSTRUCTIONAL AIDS: Chalk, chalkboard, and eraser

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Lecture

I. INTRODUCTION (3 min)

A. Opening Statement: One of the most important areas of operation in an X-ray clinic is the darkroom. The knowledge and skill of both the radiologist and the X-ray specialist are wasted if care is not taken during processing of radiographs. One mistake in film handling can destroy their most painstaking work and add to the amount of radiation to which the patient must be exposed.

B. Objectives

1. State the advantages and/or disadvantages of each of the three types of darkroom entrances.

2. State the two types of darkroom lighting and conditions of use for each.

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*This lesson plan supersedes LP 38-520-015, 042.

3. List the items of equipment located in the manual processing darkroom on the: dryside; wetside.

C. Class Procedure and Lesson Tie-in

None.

II. EXPLANATION (40 min)

A. Darkroom Entrances

1. Single door system

a. Construction

b. Disadvantages: Film bin and cassettes must be closed before the door can be opened.

c. Advantages: Requires a minimal installation space.

2. Double door (light-lock) system

a. Construction

b. Disadvantages: Requires more space than a single door entrance.

c. Advantages: Technicians can enter and exit without shutting down work.

3. Maze

a. Construction

b. Disadvantages: Requires more space than all other types of entrances.

c. Advantages: No doors to open and close; ventilation also provided.

QUESTION: Of the three types of darkroom entrance, which is the most practical?

ANSWER: Maze.

B. Darkroom Lighting

1. White light

a. Purpose

b. Precautions

NOTE: PAGE [illegible] HAS BEEN [illegible] HOWEVER, ALL MATERIAL HAS BEEN INCLUDED.

499

2. Safelight
    - a. Wratten 6 B filter
    - b. Sensitivity of film
    - c. Systems of lighting
        - (1) Direct--disadvantages
            - (a) Hot spots
            - (b) Darker room
        - (2) Indirect--advantage

QUESTION: What is the size of the bulb used in a Wratten 6 B Series safelight?

ANSWER: Ten watts (recommended) - 15 watts (maximum).

C. Darkroom Layout

1. Dry side
    - a. Workbench
    - b. Film bins
    - c. Cabinets
    - d. Film hangers
    - e. Passbox
2. Wet side
    - a. Sink
    - b. Master tank
    - c. Processing tanks
        - (1) Developer
        - (2) Stop bath or first rinse
        - (3) Fixer
        - (4) Second rinse (optional)

        d. Wash tank

    3. Refrigerator unit

    4. Dryers

D. Miscellaneous

    1. Ventilation

    2. Mops

    3. Towels

III. SUMMARY (2 min)

A. Review of Main Points

    1. Darkroom entrances

    2. Lighting

    3. Darkroom layout

B. Closing Statement: Processing the film completes the procedure which began with positioning the patient, the film, and the X-ray tube. It produces a permanent record which remains on file in the hospital or which can be transferred with the patient. With adequate equipment, processing can be done properly, and the specialist can do full justice to the films which he has exposed.

501

ACADEMY OF HEALTH SCIENCES *IM 38-520-018
MEDICINE AND SURGERY DIVISION 018
X-RAY BRANCH

Darkroom Construction

One of the most important areas of operation in any X-ray clinic is the darkroom. The knowledge and skill of both the radiologist and the X-ray specialist are wasted if care is not taken during processing of radiographs. One mistake in film handling can destroy their most painstaking work and add to the amount of radiation to which the patient must be exposed.

The entrance to the darkroom is an important consideration in the well run clinic. The single door system uses a single door between the darkroom and the white light. Naturally, this door must be well sealed around the edges to prevent the passage of light. The door must also be provided with a lock to prevent accidental exposure of unprocessed film should someone enter during the time sensitive films are out. No one can enter or leave while the film is being handled and this is the big disadvantage. It is also difficult to provide adequate ventilation with a single door entrance. The single door is usually employed where space is unavailable for another type of entrance.

The double door or light-lock system uses a short hall with a door at either end. Naturally, if one door is kept closed at all times, there is no danger of light entering the darkroom. An automatic locking device is often placed on the doors so that when one door is opened, the other is automatically locked. Sometimes, a light signal arrangement is deemed sufficient and when a door is opened, a red light, on the other side, turns on indicating that the other door should not be opened. Although this will usually be sufficient protection, it does not stop persons from opening both doors at once. The ventilation problem is present since it is difficult to get an adequate flow of air through the light-lock system. The advantage of the light-lock system is that people may enter and exit the darkroom, practically at will. This type of entrance does require a large amount of space.

The maze is the most desirable type of darkroom entrance. The maze consists of a twisted tunnel. Since light travels in straight lines and since the reflection around the corners is kept to a minimum by using flat black paint, very little light can enter the darkroom through the maze. The maze is usually about 30 inches wide and it is not easy for persons to pass each other, so it is usually required that a person entering the darkroom say, "coming in," and a person leaving should say, "coming out," before entering the maze. This prevents collisions in the dark maze. The biggest disadvantage of the maze is the space it takes up in the clinic.

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*This instructor's manuscript supersedes IM 38-520-015, 042.

The advantages of the maze lie in the easy exit and entrance during film processing and the fact that it is an open passageway which allows for easy flow of air for good ventilation.

The darkroom is divided into a dry side and a wet side on which the film is handled in the dry and wet stages, respectively. The dry side of the darkroom includes the workbench on which the cassettes and cardboard holders are handled; the film bins in which unexposed film is stored; cabinets in which unmixed chemicals, mixing equipment, etc., is stored; and brackets on which film hangers are kept ready for use.

Usually also employed on the dry side is a passbox. The passbox is the device which is used to allow film holders to enter and leave the darkroom without allowing white light to enter. It consists of a box divided down the center with double doors at each end. The doors are provided with a locking device so that when doors on one side are open, the doors on the other side are locked. The compartment on one side of the passbox is for exposed films to enter the darkroom while the other compartment is for unexposed films to leave. Clinics will vary in their passbox rules, but here at school, we have three passbox rules which you must remember. The first rule is to prevent mixing of exposed and unexposed films, and is "in on the left and out on the right." The second and third rules are for assisting the darkroom specialist in handling the film holders. The second rule is "Bakelite to the left," and the third rule is "tab end in first."

The wet side of the darkroom usually has a sink for obtaining water to mix solutions and in which paddles are kept for stirring the developer and hypo. The master tank is divided into three compartments. The first compartment has circulating water in which the developer tank is placed for temperature control, and which is used as a rinse area in the absence of an acid rinse. The second compartment has circulating water in which the fixer tank is placed. The third compartment is used for washing the film.

White lighting in the darkroom must be used continuously and these lights should be on only when cleaning the area or preparing processing solutions. The white light must be out at all times when film bins are open or when film is being handled & processed. As a precaution, the light switch should be placed in an out of the way location where possibility of accidental exposure is minimized.

Safelight is supposedly "safe" to use while handling film. Actually, the film can be fogged by overexposure to safelight. Since X-ray film is especially sensitive to the blue-violet portion of the spectrum and relatively unsensitive to the red-yellow end of the spectrum, safelights are usually either amber or red in color. In the X-ray darkroom, the amber colored Wratten 6 B filter is used in preference to the red color. The eye is more sensitive to amber than to red light and it is easier to see in the darkroom using the 6 B filter. With this filter, a lamp of no more than 15 watts should be used. Since the film is not completely insensitive to the action of safelight, care should be taken that the film is not exposed too long. At a distance of 3 feet, a film should be exposed to the direct action of the safelight for no more than 1 minute. At 10 feet, this time may be increased to 10 minutes.

There are two systems of safelighting. The direct lighting system uses lights which are directed toward the work area. The light is concentrated on the work area and forms "hot spots" of rather high intensity while the remainder of the room is left relatively unilluminated. Indirect lighting uses the principle of reflection of the light from the walls and ceiling. This method of lighting is more desirable since the room is more uniformly lighted and there are no areas of high illumination which are more likely to fog the film. The darkroom is psychologically more desirable when it is possible to see better and indirect lighting improves visibility in the darkroom.

The processing tanks are usually of a 5- or 20-gallon capacity. The developer tank has water circulating about it and is kept at about 68° F. The developer should be stirred before use after sitting for an hour or more unused. It should also be stirred at any time fresh replenisher is added.

The stop bath tank, when used, is placed next to the developer tank in the first compartment of the master tank.

The fixer tank temperature is not quite as important as that of the developer. The temperature difference between the developer and fixer should not be great however.

The wash tank should be connected to a supply of water sufficient to cause a change of water in the tanks eight times per hour. The wash tank has a ledge along the side for the support of the film hangers while washing.

A refrigerator unit is used for providing cold water. This water is mixed with tapwater during warm weather to keep the water around the developer and fixer tanks at about 68° F.

Dryers are used to blow hot (120° F.) air across the wet films. The use of a dryer reduces the streaks which may form on the film and greatly increases the speed of drying.

Darkroom ventilation is an important factor in comfort of the specialist. Ideally, filtered air should be blown into the darkroom and have a free exit through a maze or light-tight louvers. The high temperature and humidity of the dryers with the odors of evaporating solutions can make the darkroom unbearable without ventilation.

Mops and towels are some miscellaneous devices found in the darkroom to help keep it clean. Cleanliness is a very important part of processing radiographs.

We will (later) go into the darkroom to see how it is actually laid out. You must see how the equipment is placed in the darkroom and understand how to use it.

Processing the film completes the procedure which began with positioning the patient, the film, and the X-ray tube. It produces a permanent record which remains on file in the hospital or which can be transferred with the patient. With adequate equipment, processing can be done properly and the specialist can do full justice to the films which he has exposed.

505

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

Mr. John Mayes
*LP 38-520-014
016

Darkroom Processing (4 hours)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom and Darkroom

REFERENCES: TM 8-280, Selman, Joseph . . .pp. 278-296.

STUDY ASSIGNMENT: Before class read TM 8-280, pp. 7-20 thru 7-44, para 7-26 thru 7-56.

TOOLS, EQUIPMENT, AND MATERIALS: None

PERSONNEL: One instructor (X-ray Branch) 1st and 2d hours; three instructors (X-ray Branch) 3d, and 4th hours.

INSTRUCTIONAL AIDS: Chalk, chalkboard, eraser; One exposed film for each student; Manual processing darkroom furnished with all typical equipment.

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Lecture (1st and 2d hours); practical exercise (3d and 4th hours)

FIRST AND SECOND HOURS

I. INTRODUCTION (5 min)

A. Opening Statement: The x-ray film is the one thing which carries through the complete system in the x-ray clinic. The whole purpose of x-raying a patient is to produce a film which displays diagnostic quality of the anatomical structure radiographed. It is, therefore, very important that we know how to process the film in order to achieve this desired quality. This period, we will study the chemical processing of the image on a film. A good knowledge of this will best demonstrate radiographic film quality. Later, you will be required to process a film which demonstrates this quality.

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*This lesson plan supersedes *LP 38-520-014, 062

506

B. Objectives

1. State (when using the hand processing system) the:

   a. functions of developer, rinse, fixer, wash in film processing.
   b. factors which affect film development time.
   c. duration of processing in each chemical solution.
   d. effect on a film of any of the following incorrect procedures:

      1) develop but not fix.
      2) fix but not develop.
      3) insufficiently wash.

2. Describe (when using the hand processing system) the:

   a. order of use of chemical solutions.
   b. methods of film handling.

C. Class Procedure and Lesson Tie-in

Lecture (1st and 2d hours); Practical Exercise (3d and 4th hours).

II. EXPLANATION (80 min)

NOTE: Refer to Annex A for print outline. (Students using GR 38-520-001-1, 084 have major headings filled in and must fill in their notes as per Annex A.)

III. SUMMARY (5 min)

A. Review of Main Points

   1. Functions of developer, rinse, fixer, wash; duration in each position.
   2. Factors affecting development time.
   3. Effects of improper processing.
   4. Correct methods of film handling in chemical solutions.

512

507

B. Closing Statement: Although it is not necessary to learn the exact reactions that take place in development and fixing, the Specialist should have some understanding of the basic actions of the processing chemicals. For proper production of a good quality radiograph, it is also necessary to understand the theory and controlling factors of processing. Processing is the final controlling factor that will determine the diagnostic quality of a film.

508

LP 38-520-014
016

THIRD, AND FOURTH HOURS

I. INTRODUCTION (5 min)

A. Opening Statement: It is important to know the theory of manual processing systems, but it is equally important to put this theory to use in practical application of processing radiographs. Today, you will get your first opportunity to actually process an exposed film of a part and bring out the final resulting product which will be a diagnostic radiograph.

B. Objectives

1. Observe proper manual and automatic processing machine methods.

2. Under supervision of instructors to process previously exposed films using manual and automatic processing machines.

C. Class Procedure and Lesson Tie-in

Relates to hours previously presented on manual processing solutions, chemicals, systems and controlling factors.

II. APPLICATION (80 min)

NOTE: Refer to Annex B for further explanation of Laboratory Exercise.

A. Student's Activities

1. Use proper technique in entering darkroom through the type of entrance provided.

2. Carry out proper preparatory procedures for manual processing of film.

3. Properly perform processing of a film issued by the instructor using the replenisher system of developing and fixing.

4. Examine finished radiograph and determine if processing procedure was carried out properly.

5. After critique by instructor, place film in dryer to be dried and clean processing equipment.

6. Make exposure of dry bones (skull) plastic hands or feet for processing by other students in manual darkroom.

7. Process previously exposed films in automatic processor.

B. Instructors' Activities

1. Supervise students in producing exposed films of dry bones.

2. After entering darkroom with students, give a general orientation on darkroom responsibilities for dry side and wet side.

3. Give orientation on darkroom operation in machine processing.

4. Point out features of manual processing listed in the lecture on the replenisher systems of processing.

5. Supervise students throughout the entire processing procedures.

6. After all films are in the wash, critique each film's results to the entire class.

III. REVIEW or CRITIQUE (5 min)

A. Questions From Students

B. Review of Main Points

1. Errors in handling film
2. Errors in processing technique

C. Closing Statement: Practical exercises are a very effective way to learn your weak and strong points in a given procedure. The procedure you performed today is essential to produce a diagnostic quality radiograph which is the final product of your work. Employing proper theory and effective technique will consistently give you the highest quality of the finished product, a diagnostic radiograph.

510

LP 38-520-010
016

INSTRUCTIONAL HOURS

Number of instructors required --- 3

Primary hours --- 8

Secondary hours -- 0

Total --- 8

516

ANNEX A
INSTRUCTIONAL AIDS

DARKROOM PROCESSING

A. Processing of Latent Image

1. Developer

a. Function

Change exposed AgBr to black metallic silver.

b. Constituents

1) Reducers - change AgBr to black Ag

   a) Hydroquinone - slow acting, does not act below 60°F, above 70°F produces fog. Provides Contrast

   b) Elon (metol) - fast acting, not much affected by temperature. Provides overall density

$$R^{\circ} + Ag^{+}Br^{-}(\text{exp}) \qquad R^{+}Br^{-} + \underset{\uparrow\text{density}}{Ag^{\circ}}$$

2) Activator - provides slightly alkaline solution so reducers can work and softens emulsion.

   Sodium carbonate (Na_2CO_3) - regular developer
   OR
   Sodium Metaborate ($NaBO_2$) - rapid developer

3) Restrainer - prevents reducers from attacking the unexposed AgBr

   Potassium Bromide (KBr)

4) Preservative - prevents oxygen from attacking reducers

5) Solvent - dissolve all other constituents and make them chemically active. Water

2. Fixer (Hypo)

a. Function

To remove ALL AgBr from the film. (To clear the film.)

b. Constituents

1) Clearing Agent - Removes ALL AgBr
   Sodium thiosulfate ($Na_2S_2O_3$)

2) Hardening Agent - Hardens or "tans" emulsion so it is more durable, resists scratching.
   Potassium Alum ($KAl(SO_4)_2$)

3) Acidifier - Neutralizes developer, stops development
   Acetic Acid (CH_3COOH)
   OR
   Sulfuric Acid (H_2SO_4)

4) Preservative - Stops action of oxygen on clearing agent. Sodium Sulfite (Na_2SO_3)

5) Solvent - dissolves and makes active all other constituents (H_2O)

B. Factors Affecting Development Time

1. Temperature - Normal 68°F (Normal Range 60 - 75°F)
   Higher temperature reacts more rapidly (±15 sec/deg)

2. Solution Strength - If initially mixed properly should depend only upon use of solutions.

3. Type of developer - at 68°F
   Rapid - 3 min
   Regular - 4½ min

4. Type of Film
   Screen Type - Normally used
   Direct Exposure - Thicker emulsion - longer development

C. Systems of Processing

1. Development-Replenisher

a. Theory By adding extra strength chemicals as solution is being used overall strength remains constant so development time remains constant.

b. Characteristics

1) Film Transfer - NO DRIP back into developer

2) Solution Level - Add EXTRA strength developer (replenisher) to maintain solution level

3) Time of Development - Remains constant

4) Strength - Remains constant

5) Discard when 3 to 4 times volume of tank has been used in replenishing OR after 3 months, whichever occurs first.

c. Rate of REPLENISHMENT

Add replenisher as level drops

Discard after 3 to 4 times volume of replenisher has been used OR after 3 months, whichever occurs first.

514

2. Systems of Rinse

a. Time

15 to 20 sec between development and fixer

b. Types of Rinses

1) Running Water - Most Common

2) Stagnant Water - Field Conditions

3) Acid or Stop Bath - Theoretically Best
   Acetic Acid in water

3. Fixing--Replenishment System

a. Theory Remove and discard solution periodically and add replenisher so strength remains constant.

b. Characteristics

ALWAYS drip back to fixer tank.

LEVEL remains same

c. Rate for 5 Gallons Fixer

	Time	Films	Procedure		
(1)	5 min.	0-50	Remove 2 qts.	Add 2 qts.	"SPIKE"
(2)	5 min.	51-100	" " "	" " "	"
(3)	5 min.	101-150	" " "	" " "	"
(4)	6 min.	151-200	" " "	" " "	"
(5)	7 min.	201-225	" " "	" " "	"
(6)	8 min.	226-250	" " "	" " "	"

(7) Discard after 250 films or 3 months.

(All above information already printed in student's GR)

F. Optional Rinse

2 to 5 seconds

Main reason for using it is that it considerably shortens wash time.

G. Wash System

1. Single Tank 20 to 30 min - Left to right film transfer.
   Should have at least 8 volumes of water flow thru tank per hour.
2. Cascade System - 10 minutes in each tank.

H. Drying System

Cabinet with forced air at about 120°F.

ANNEX B
INSTRUCTIONAL AIDS

DARKROOM PROCESSING--LABORATORY EXERCISES

I. Exposing Films

Sufficient films are pre-exposed so that one third of the group in Lab will have one film each to develop in the manual processing darkroom and one third will have one film each to develop in the automatic processing room. These films are initially placed in the passbox of each darkroom for the use of the first group in each position.

Subsequent films will be exposed by the students themselves as needed.

II. Instructors

Three instructors are required. One in the Exposure Room (A), One in the Automatic Processing Room (B) and One in the Manual Processing Room (C).

III. Students

Students are initially divided into three groups (a, b & c) and are assigned to the three locations indicated in II, above. After approximately 40 minutes group a moves to location B, group b moves to location C and group c moves to location A. This is repeated so that each group has spent about 40 minutes in each location.

IV. Locations

A. In the Exposure Room (Location A) each student takes two films on dry bones. One film goes to Location B and one to Location C for use by the next group of students at that location.

B. In the Automatic Processing Room (Location B) students have proper automatic processing procedures demonstrated and each student develops one film.

C. In the Manual Processing Room (Location C) students have manual processing procedures demonstrated and each student develops one film.

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DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

Mr. John Mayes
*IM 38-520-014
016

Darkroom Processing

The x-ray film is the one thing which carries through the complete system in the x-ray clinic. The whole purpose of x-raying a patient is to produce a film which displays diagnostic quality of the anatomical structure radiographed. It is, therefore, very important that we know how to process the film in order to achieve this desired quality. This period, we will study the chemical processing of the image on a film. A good knowledge of this will best demonstrate radiographic film quality. Later, you will be required to process a film which demonstrates this quality.

As you will recall, the exposed x-ray film has been sensitized to form the latent image. The latent image is not visible and must be brought out by processing to become readable by the radiologist.

To bring out the image on the film, a process called development is performed. The film is placed in a solution of many different chemicals. This solution, the developer, changes the silver bromide crystals which were exposed to black metallic silver. The developer is specially compounded to restrain the chemicals from attacking the unexposed silver bromide crystals, for the most part, they remain as unchanged silver bromide. During the development, the exposed areas of the film become dark, the degree of darkness depending on the degree of exposure. The unexposed silver bromide crystals remain in the film imparting a greenish cast to the relatively unexposed areas of the film.

The greenish color, due to unprocessed silver bromide, must be removed from the film. This process occurs in a second chemical bath called the hypo or fixer. The chemicals in the fix remove the silver bromide, thus clearing the film in the unexposed areas. The silver areas of the film are left unaffected so the image left after clearing is just as it appears in the final film. Another action, that of hardening, shrinks the emulsion making it resistant to scratches in the dry state.

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*This instructor's manuscript supersedes IM 38-520-014, 062

518

During this period, you are going to learn the action of the various constituents and their chemicals in the processing solution. If you understand the actions of each of these chemicals, you will understand the limitations of the solutions and the need to rigidly regulate the darkroom conditions.

The basic action of the developer is to change the silver bromide crystals to black metallic silver. We have already discussed the basic action in connection with the latent image. The developer is specifically made to attack the exposed silver bromide crystals only and to leave unaffected the unexposed crystals.

The materials in the developer that change the silver bromide to silver are called reducers. There are two different reducers in the developer. The less active of the two is hydroquinone which is slow-acting and does not react at all under temperatures below 60 degrees Fahrenheit. Above 70 degrees Fahrenheit, hydroquinone tends to cause fog on the film. The higher the temperature, the more fog is produced. The ideal development temperature is 68 degrees Fahrenheit, because this is about as warm as the solution can be to increase the speed of reaction and still stay below the point of excess fog due to high temperature. The purpose of the hydroquinone is to provide contrast to the finished film. The maximum development temperature is 75 degrees Fahrenheit for manual processing.

The second reducer is called elon or metol. It is fast-acting, not much affected by temperature and provides an overall density to the film. By properly balancing the amounts of elon and hydroquinone, the proper scale of contrast can be produced on the film.

The reducers would be entirely ineffective were it not for the activator (sodium carbonate). The activator acts in two ways to speed development. Firstly, it quickly softens the gelatin emulsion of the film so the chemicals can rapidly enter and process the image. Secondly, it provides an alkaline solution without which the reducers simply cannot work. Sodium carbonate is less active and is found in regular-type developer solution. A rapid type of developer solution is also available which works faster than regular. It employs sodium metaborate (Kodalk) as its activator.

Were it not for the restrainer, the reducers would change all silver bromide to black silver. The restrainer holds down or restrains developer action on the unexposed crystals while allowing the development to occur on the exposed crystals. The chemical potassium bromide is used as the restrainer.

The preservative sodium sulfite helps to lengthen the life of the developer by reacting with dissolved oxygen, preventing it from attacking and destrouing the effectiveness of the reducer.

The solvent dissolves all the chemicals, makes them active and able to penetrate into the emulsion of the film. Water is, of course, used for this purpose.

The purpose of the hypo or fixer is to remove all silver bromide salts from the film. The silver image which is formed on the film in development is left unchanged but the remaining silver bromide is removed. This action is also called clearing. The emulsion is also shrunk as water is removed and hardened so it will resist scratching when dry.

The chemical in the fixer which removes the silver bromide is called the clearing agent. This chemical is sodium thiosulfate. An older name, sodium hyposulfite, is sometimes used for this chemical from which the name hypo is derived. Silver bromide is ordinarily insoluable in water, but the addition of sodium thiosulfate quickly dissolves the silver salts.

The action of hardening the emulsion is very similar to the reaction of tanning leather. Potassium alum is used as the hardening agent. The alum attacks the protein molecules of the gelatin shrinking the emulsion and forcing out water. Proper hardening of the emulsion greatly speeds the drying process and hardens the emulsion to avoid later abrasion of the emulsion.

The process of development will continue while the film is being fixed if the developer chemicals still in the emulsion are not neutralized. The acidifier, usually acetic adid, is used for this purpose. The acid neutralizes the caustic activator preventing the reducers from being active. This stops development of the film almost as quickly as it is placed in the fixing solution.

The preservative in the fixer keeps oxygen from attacking the sodium thiosulfate and precipitating out sulfur. The same preservative is used in the fixer as is used in the developer--sodium sulfite.

The solvent dissolves the chemicals making them active and is, of course, water.

Some x-ray clinics use a rinse between the developer and hypo which as an acid and which will stop the action of development more rapidly than an ordinary water rinse. This type of rinse is called a stop bath. The acid is usually a moderately strong solution of acetic acid. The use of the stop bath lengthens the life of the fixer.

The duration of development is affected by several different factors. We will consider these and discuss just how the time should be changed depending on these factors.

The temperature of the developer is an essential consideration. The warm developer is more active than the cool developer. The time of development will be shorter the warmer the solution. With the cool developer, the processing time is markedly increased. The ideal development temperature is 68 degrees Fahrenheit and developer temperature above or below this value require decreases or increases of processing time.

The strength of the solution affects the activity and thus the duration of development. Two factors influence the strength of the developer--the age and the usage. When the developer sits for long periods of time, even though it is not used, the action of oxygen from the air and light striking the solution will cause the active chemicals to decompose, thus reducing the activity of the solution. Of course, the amount of use determines how many chemicals are worn out. Those chemicals which have once been used are no longer of any use in further processing. Naturally, the weaker the solution is, the longer the development time must be.

The type of film used is also a factor which determines the proper time of development. There are two types of x-ray film which may be used, direct exposure-type and screen-type film. Direct exposure film is designed to be used only in cardboard holders and has a thicker emulsion (for more exposure the action of x-rays) which requires a longer time for the developer to penetrate and work. The screen type of film is used in cassette with intensifying screens and requires less time for processing. Since it is difficult to keep these types of films separated for both exposure holders and for processing, the Army uses only screen-type film. Screen type film requires a greater exposure than direct exposure film when it is used in cardboard holders, but keeping the two types of film separated in the darkroom is difficult, so the Army uses screen-type only.

Two types of developer are produced and the development times are different. The regular developer uses sodium carbonate as an activator and uses a basic 4½ minute development time while the rapid developer uses the more active sodium metaborate and can produce similar film in three minutes or less. The Army usually uses only the rapid type of developer, so ordinarily you will have no problem with the type of developer in your processing time

In some x-ray clinics, the development time is visually checked, depending on the amount of exposure. This process, called sight development, is highly unsatisfactory and should be used only in emergency situations. Sight development will not produce uniform results since the estimation of processing termination will vary considerably from individual to individual, and even for the same individual depending on his dark adaptation, his vitamin A intake, and the type of exposure (both different parts and exposures on cassette versus cardboard holders affect the developing time estimation). The x-ray films should all be properly exposed so all can be properly and uniformly processed to consistently produce good quality radiographs.

The replenisher system is based on the concept of keeping the strength of the solution constant so the development time will depend only upon the temperature. An increase of each degree Fahrenheit requires a decrease of 15 seconds in development time. A decrease of temperature requires the same increase in development time. This is accomplished by adding extra strength developer called replenisher to the tank periodically. If the films are not allowed to drip back into the developer tank before rinsing, most of the more worn out chemicals are carried out of the developer leaving behind the more active ones. Moreover, carrying out this extra solution will remove approximately a gallon of solution for every 40, 14 x 17 films. If extra strength replenisher is added to keep the solution level up, the strength is kept at the same level for all practical purposes. An abundance of fresh circulating water is needed for rinsing after developing.

If the solution has been replenished with from three to four times the original volume of developer or even if it has been unused for three months, it should be discarded and replaced with fresh developer.

5222

The film is rinsed to remove excess developer from the film. If this is not done, the developer will neutralize the chemicals in the fixer, making them inactive. Usually, the rinse is a water rinse, but sometimes an acid rinse is used. The acid stops the action of the developer and is sometimes called a stop bath. The film should be rinsed from 15 to 20 seconds and allowed to drip back to rinse about 10 seconds before placing in the fixer. The acid bath consists of two and one-half quarts of 28 percent solution of acetic acid to one gallon of water; stir thoroughly; add sufficient water to make five gallons of solution.

The replenisher system of fixing is based on the idea of keeping the strength of the fixer approximately constant so the time of fixing will remain unchanged. In practice using five-gallon tanks, the fixer should be replenished at the rate of two quarts for each 50, 14 x 17 films. Using 20-gallon tanks, this is accomplished by removing 2 gallons of replenisher for each 200, 14 x 17 films processed. Replenisher for the fixer is no different than the ordinary fixer with the exception that it is a more concentrated mix. The characteristics of this system are similar to that of the replenisher in development with the exception of a slight change in time and in fixing. You never drip solution over--always back.

During the fixing of the first 600 films (using a 20-gallon tank), the fixing time is kept constant at 5 minutes; but with each replenishment thereafter, the fixing time should be increased by 1 minute until 10 minutes fixing time is reached. This will mean that 1,000, 14 x 17 films or their equivalent have been processed and the fixer should be discarded and fresh solution made.

Washing time is dependent on the efficiency of the washing system and the temperature of the wash water. Warmer wash water is more efficient than cooler water. Using the cascade system of washing, water from a second wash tank overflows or cascades into the first wash tank. The films are washed in the first tank for approximately five minutes to remove the greater portion of the fixer chemicals; the second tank is employed for another 5 minutes. If, howerer, a single tank continuous flow is used in washing films, the total washing time is much longer. With a flow such that a volume of water in the tank is replaced eight times per hour, a washing time of 20 to 30 minutes is required. Less flow than this may require much longer wash time.

Drying time is dependent upon several factors of processing: hardening of emulsion, water retained in the emulsion, temperature of the drying system, humidity, and use of drying aids. An effective drying system utilizes circulating air and heat and will dry in about 15 to 30 minutes. In this system it is recommended that the temperature be kept below 90 degrees Fahrenheit with less than 50 percent humidity. This will allow rapid drying and prevent blistering of the emulsion.

To decrease drying time, an effective wetting agent can be used as a drying aid in a rinse after wash. This is a detergent that will reduce the surface tension of the water so it can drain off the film surface more rapidly. There is no specifically recommended wetting agent, for there are many different types. To prepare this solution, add 2.5 ounces of wetting agent detergent to 5 gallons of water. Rinse 30 seconds after the wash, then dry.

Practical exercises are a very effective way to learn your weak and strong points in a given procedure. The procedure you performed today is essential to produce a diagnostic quality radiograph which is the final produce of your work. Employing proper theory and effective technique will consistently give you the highest quality of the finished produce, a diagnostic radiograph.

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

Mr. John Mayes
*LP 38-520-016
036

Artifacts (3 hours)

COURSE PRESENTED TO: 313-91P20 Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES: TM 8-280, Selman, Joseph, 5th ed. 1972 pp 285-290.

STUDY ASSIGNMENT: Before class, TM8-280, pp. 7-45 thru 7-47, Table 7-4

STUDENT UNIFORM AND EQUIPMENT: TM 8-280, GR 38-520-001-1.

TOOLS, EQUIPMENT, AND MATERIALS: NA

PERSONNEL: One instructor (91P2H or 91P4H)

INSTRUCTIONAL AIDS: Artifact film file: #1 Exposure Room Artifacts; view boxes; #2 Dry Side Darkroom Artifacts; #3 Wet Side Darkroom Artifacts.

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Lecture (3 hours)

FIRST HOUR

I. INTRODUCTION (5 min)

A. Opening Statement: It is quite easy to mishandle films in such a way as to produce artifacts. Although some artifacts may not impair film quality, most do, and all artifacts are undesirable. Artifacts should be avoided at all times.

B. Objectives

Given a specific artifact (developer splash, fixer splash, static electricity, dirty or damaged screens, light fog, crinkle marks, foreign object) state:

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*This lesson plan supersedes LP 38-520-0160, 087

1. At what point in handling it was produced.
2. How it would appear on the film in terms of:
   a. Characteristic shape or appearance.
   b. Dark vs light.
3. Which technologist was responsible for producing it.
4. How it was produced.
5. How it could have been avoided.

C. Class Procedure and Lesson Tie-in: None

II. EXPLANATION (130 min)

A. Artifact--definition

B. Exposure Room Artifacts

NOTE: Show films from packet F 38-520-016-1 (See Annex A).

1. Mishandling equipment
   a. Sandbag
   b. Sandwich board
   c. Grid
   d. CR light
2. Radiopaque articles on patient
   a. Hairpins
   b. Dentures
   c. Brassiere hooks
   d. Buttons
   e. Belts
   f. Medals, dogtags, etc.

C. Darkroom Artifacts

1. Dry Side

NOTE: Show films from packet F 38-520-016-2 (See Annex A)

- a. Film handling
  - (1) Crinkle marks
    - (a) Appearance
    - (b) Cause
  - (2) Static electricity
    - (a) Appearance
    - (b) Cause
  - (3) "Kissed" films
    - (a) Appearance
    - (b) Cause
- b. Film holder artifacts
  - (1) Double loaded holders
  - (2) Improperly loaded holders
    - (a) Cardboard
    - (b) Cassette
- c. Exposure to light
  - (1) "Safe" light
  - (2) White light.

2. Wet side Artifacts

NOTE: Show films from packet F 38-520-016-3 (see Annex A)

527

- a. Light fog
    - (1) White light--reversed image
    - (2) "Safe" light--fog
- b. Temperature fog--above 70° F.
- c. Scratched emulsion
- d. "Kissed" films
- e. Improper fixing
- f. Emulsion bubbles or blisters
    - (1) Appearance
    - (2) Cause
- g. Staining of dry film--underwashed
- h. Emulsion slough
    - (1) Overwashed
    - (2) Warm wash
    - (3) Insufficiently hardened
- i. Scum on film
- j. Drying artifacts
    - (1) "Kissing"
    - (2) Reticulation

D. Questions from Students

III. SUMMARY (5 min)

A. Review Main Points

- 1. Exposure room
- 2. Darkroom--dry side
- 3. Darkroom--wet side

B. Closing Statement: Only if you know how artifacts are caused, will you be able to prevent them. You will be responsible for eradication of the causes of artifacts.

ANNEX A
INSTRUCTIONAL AIDS

Artifact Film File

F 38-520-016-1	Exposure Room Artifacts
F 38-520-016-2	Darkroom-Dry Side Artifacts
F 38-520-016-3	Darkroom-Wet Side Artifacts

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DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

Mr. John Mayes
*IM 38-520-016
036

Artifacts

It is quite easy to mishandle films in such a way as to produce artifacts. Although some artifacts may not impair quality, most do, and all artifacts are undesirable. Artifacts should be avoided at all times.

Exposure room artifacts

Most artifacts are produced in the darkroom but the few which are produced in the exposure room are produced by mishandling the x-ray beam or by interspacing some object between the tube and the film. This film, for example, shows how a sandbag can cover an area of the film. In this particular film the sandbag does not interfere with the diagnostic quality of the film, but supposing it showed in an area necessary for film diagnosis?

In this film a sandwich board was slipped during the second exposure. See the area of double exposure. Care must be taken to avoid sliding the sandwich board during exposure.

If the grid does not move during the exposure, grid lines will be formed. To avoid this, make sure the Bucky is activated before the exposure is made.

When using machines with videx cones the CR light must move out of the way before the exposure is taken. These films show the image of the CR light on the film.

Radiopaque objects which show on the film are just as much the specialist's fault as are the artifacts due to mishandling the accessories. The patient does not understand that x-rays will not penetrate everything. The patient does not know that all foreign objects must be removed from his person in the area under consideration. In women, hairpins and brassiere hooks will show up in radiographs of the skull and chest. These articles must be removed prior to exposure and this must be explained to the patient. Similarly, on men all articles of clothing having buttons in the area under consideration must be removed as should belts and metallic objects such as necklaces, keys, dogtags, and so forth.

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*This instructor's manuscript supersedes IM 38-520-0160, 087

Darkroom artifacts--dry side

Darkroom artifacts account for as much as 90 percent of the normally occurring artifacts. Darkroom artifacts may be produced on either the wet side or the dry side of the darkroom. The type of artifact usually can be readily recognized as being produced while the film is dry or wet.

Artifacts on the dry side are due usually to mishandling the unprocessed film.

Crinkle marks, as you see, are crescent-shaped areas usually having a greater density. They are caused by bending the film before processing. If the film is held horizontally with one hand it must bend. Where it bends, crinkle marks are formed. Although crinkle marks may be made in other ways, they usually are produced by handling the film with only one hand in the horizontal position.

Static electricity marks may appear as dark streaks, as branding "Christmas trees," or as star-shaped marks on the film. Static electricity is especially prevalent during cool dry periods. To avoid static electricity marks, avoid rubbing the film against any body or surface. Any time any two dissimilar materials are rubbed together static electricity can be formed, so the best way to avoid it is to avoid this friction.

"Kissed" films are films which stick together while in the wet condition in developer, hypo, wash, or dryer. This, however, must be considered an artifact caused by improper handing of the film on the dry side of the darkroom. If the film is hung so that the film is warped or bent in the hanger when they are placed in the solutions the warped portions may touch or "kiss."

Film holder artifacts may come about as a result of dirt getting in cassettes, doubly loading a cassette, or improperly loading cardboard holders or cassettes.

When two films are in the same cassette, double exposures may result since only one film will probably be removed and the other will probably remain to be double exposed with another film. This occurred with this film. Five separate radiographic procedures involving eight different exposures were made on this one film because someone could not find a film in this cassette. The film was stuck to the back screen and when another film was placed in the cassette double exposure occurred.

Film holders can be improperly loaded. The cardboard holder was not loaded with the large flap first in these films. Note the areas of light fog in the center which ruins these films.

Cassettes too, can be loaded improperly. Using a cassette, any interleaving paper must be removed from the film. No dust, film corners, etc., should be allowed to collect in the cassette. These foreign objects will absorb light from the screen keeping it from striking the film. These light areas on the film are a result of dust in a cassette. Also, the film, if not placed squarely in the cassette may overhang on the edge and be bent with an edge corner sticking out. This reduces the size of the area of film that is usefully used. Running the finger lightly around the edge of the cassette prior to closing the lid will avoid many of these types of artifacts.

If the film is exposed to light it will be fogged. Even prolonged exposure to safelight will fog it. Here, for example, is a film which had a film hanger lying on top of it while being exposed to a safelight for only 15 minutes. You can see the shadow of the film hanger. Films should never be hung and left unattended in the safelight for periods of more than 10 minutes. Any white light that strikes the film will, of course, fog the film and should be avoided at all times. All light leaks in the darkroom should be covered to reduce light fogging.

Darkroom artifacts--wet side

The wet side of the darkroom can also have fog due to light. If white light strikes a film which is in the process of development, the image may be reversed in the upper portion of the film. That is, the light areas become dark and the dark areas become light in these portions of the film.

When films are viewed before a strong safelight too often during the development, the safelight will cause a fog on the film.

Temperature too causes fog. If the developer is warmer than 70° F. fog is produced, the amount depending on the temperature.

The emulsion is easily scratched when the film is wet. Notice these long deep scratches in the emulsion. They are caused by a rather pointed object being scraped over the surface of the film.

When films touch in the developer, an area of low density appears in that portion of the film. The "kissing" effect in the hypo leaves an opalescent area on the film. "Kissing" in the wash tank will not usually show up until much later, but when the chemicals decompose a yellow to brownish stain appears.

Improper fixing leaves the emulsion soft even if the film has been cleared. The soft emulsion may be sloughed off if the films are left too long in the wash water.

533

Small bubbles may occur in the emulsion when using the regular type developer, causing the film to have a rough appearance similar to coarse sandpaper. This is caused by the sodium carbonate activator being neutralized in an acid fix which is too warm. The acid frees carbon dioxide which, in cold water, is highly soluble but in warm water it tends to form small bubbles of gas in the emulsion pulling it away from the film base in small areas.

When films have a yellow-to-brown stain all the silver salts and fixer chemicals were not washed from the emulsion. If a film is washed too short a time, this will happen. When films "kiss" in the wash tank, only the kissed area will have the stain.

The emulsion can slough off the film if it has been washed too long. Leaving the film in the wash water overnight is too long and sloughing may easily occur, especially if the wash water is too warm and the film insufficiently hardened. Warm water tends to dissolve the gelatin much faster than cooler water.

If the developer and fixer have sat for a long time without stirring, a scum forms on the surface. If these solutions are used without breaking up and stirring these scum segments into the solution, they will tend to cling to the surface of the film, leaving a stained appearance which washes off with great difficulty. A dried film may have a silvery sheen on the surface due to the silver deposits in the scum from the fixer.

Artifacts may occur in the drying in the form of "kissing.". When films "kiss" in the dryer and become completely dry it is very difficult to separate them. Commercial wetting agents are sometimes used to prevent streaking of films just before they are placed in the dryer. If a tank of this solution is available, the "kissed" films may be placed in this tank and left overnight. This will usually soften the emulsion sufficiently to peel the films apart without ruining them. The films must then be thoroughly fixed to harden the emulsion, washed and dried.

If the dryer is too hot it may cause the emulsion to be melted so that it pulls away from the film base in some areas. This is known as reticulation and should be avoided by allowing the dryer temperature to be no more than 120° F.

Only if you know how artifacts are caused, will you be able to prevent them. You will be responsible for eradication of the causes of artifacts.

ACADEMY OF HEALTH SCIENCES *LP 38-520-021
MEDICINE AND SURGERY DIVISION 018
X-RAY BRANCH

Electricity: Ohm's Law, AC and DC (4 hours)

COURSES PRESENTED TO: 313-91P10, X-Ray Specialist

PLACE: Classroom

REFERENCES:

TM 8-280
Selman, Joseph. The Fundamentals of X-Ray and Radium Physics. 5th ed. Springfield, Illinois: Charles C. Thomas, publisher, 1972, pages 70 - 80.

STUDY ASSIGNMENT: After class, study TM 8-280, pp 4-1 through 4-3, para 4-3 through 4-7.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280, GR 38-520-001 C

TOOLS, EQUIPMENT, AND MATERIALS: None

PERSONNEL: One instructor, 91P2H/91P3H/91P4H

INSTRUCTIONAL AIDS: Chalk, chalkboard, eraser; screen, overhead projector.

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Lecture (1st - 4th hours)

FIRST AND SECOND HOUR

I. INTRODUCTION (5 min)

A. Opening Statement: In order to fully understand proper exposure technique, the specialist must understand what happens inside of the X-ray machine when he manipulates the outside control knobs. The first stepping-stone to comprehension of this knowledge is an understanding of the different types of current used to operate the machine. Several weeks ago, we had a two-hour discussion on the basic principles of electricity. We are going to review those principles so that we can build from that point to new concepts of electricity.

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*This lesson plan supersedes LP 38-520-019, 034.

B. Objectives

1. List the three basic electrical factors
2. Define: AC cycle, frequency, impulse
3. Diagram: simple series and parallel circuits
4. State Ohm's Law as it applies to direct current circuits
5. State the type of current represented in a given diagram
6. State how electrical paths, voltages, currents, and total resistance compare in series and parallel circuits
7. Convert (when given the frequency) AC impulses to seconds of exposure
8. Convert (when given the frequency) seconds of exposure to AC impulses

C. Class Procedure and Lesson Tie-in: None.

II. EXPLANATION (170 min)

NOTE: Students using GR 38-520-001-1C have major headings filled in and must complete their notes as per outline.

A. Electricity

1. Definition
    - a. The effect produced by having an excess or deficiency of electrons in an area
    - b. The effect produced when electrons move from point to point
2. Three basic electrical factors (review)
    - a. Voltage
        - (1) Definition: Push or pull on electrons
        - (2) Synonyms: Potential Difference
          Potential
          Electromotive Force
          Electrical Pressure
        - (3) Unit of measurement

(a) Basic unit - volt

(b) In X-ray - kilovolt (one kilovolt = 1000 volts)

(4) Measuring instrument - voltmeter

b. Current

(1) Definition: Flow of electrons (number of electrons per second)

(2) Unit of measurement

(a) Basic unit - ampere

(b) In X-ray - milliampere (one amp = 1000 milliamps)

(3) Measuring instruments - Ammeter, Milliammeter

c. Resistance

(1) Definition: Opposition to the flow of electrons

(3) Unit of measurement - ohm

(4) Factors affecting resistance

(a) Material

QUESTION: What effect does the material have on the passage of current through a substance?

ANSWER: An element with a vast number of free electrons will readily allow current movement. An element with very few free electrons will resist the flow of current. This is called an insulator.

(b) Diameter (thickness) of wire

(c) Length of wire

(d) Temperature of wire

B. Ohm's Law

1. Statement of law: The current is directly proportional to the applied voltage and inversely proportional to the resistance in a direct current circuit.

2. Symbols

E = voltage (volts)

I = current (amperes)

R = resistance (ohms)

3. Formulas

$$I = \frac{E}{R}$$

$$E = I \times R$$

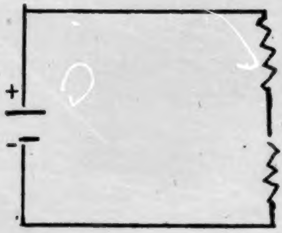
$$R = \frac{E}{I}$$

C. Circuits

1. Definition: A circuit is a closed loop of wire containing a voltage, current, and a resistance

2. Types

a. Series

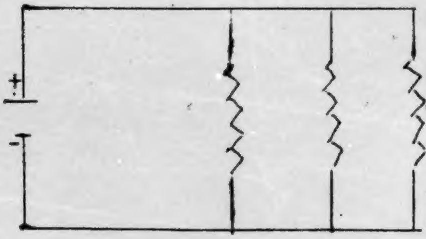


I (current) is the same throughout a series circuit

E (voltage) divides

R (resistance) varies, depending on the number and size of the individual resistances

b. Parallel



I (current) divides

E (voltage) is the same throughout a parallel circuit.

R (resistance) varies again depending on the number and size of the individual resistances

c. Summary

	PATHS	VOLTAGE	CURRENT	RESISTANCE
SERIES	All circuit elements connected in a line along same conductor (one path)	Sum of voltages equal to total circuit voltage	Current through each circuit element is the same and equal to total circuit current	Total resistance equal to sum of individual resistances
PARALLEL	Contains elements that bridge circuit (multiple paths)	Voltage across each circuit element same and equal to total circuit voltage	Sum of currents thru each element equal to total circuit current	Total resistance inversely proportional to the sum of the reciprocals of each ind. res.

D. Types of Dynamic Electricity and Waveforms

1. Direct current

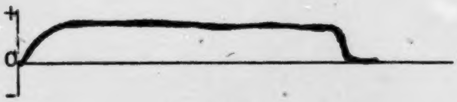
   a. Definition: A current flow in which the electrons travel in only one direction through the wire

   b. Types

      (1) Uniform direct current

         (a) Definition: A current flow in which the electrons travel smoothly (at a constant speed) through the wire

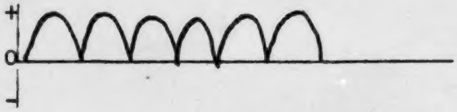
         (b) Waveform



      (2) Pulsating direct current (needed for X-ray production)

         (a) Definition: A current flow in which the electrons are constantly changing speed as they flow.

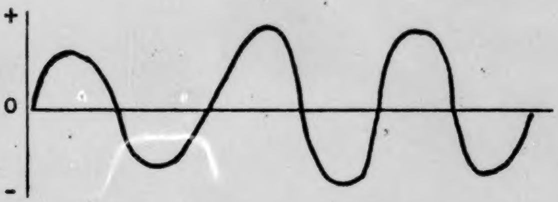
         (b) Waveform



2. Alternating current

a. Definition: A current flow in which the electrons are continually changing direction and speed as they travel

b. Waveform



c. Terminology

(1) Cycle - the complete reversal of an alternating wave

(2) Frequency - the number of cycles per second

QUESTION: What is the frequency of United States alternating current?

ANSWER: In the United States, the frequency is 60 cps; overseas, 50 cps.

QUESTION: What is the difference between AC and pulsating DC?

ANSWER: The main difference is the direction in which the current moves. AC changes direction, but pulsating DC flows only in one direction.

(3) Wavelength - the linear distance of travel of one cycle

E. Impulse-Time Relationship

1. Each "peak" in an alternating current waveform is an impulse. Therefore, there are two impulses per cycle. In the United States - alternating current. Since there are 60 cycles per second, there are 120 impulses per second possible in a full-wave machine. Overseas, where there are only 50 cycles per second, there are 100 impulses per second.

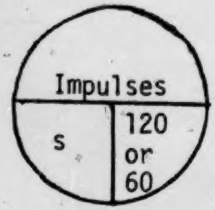
2. X-ray machines change (convert) AC into pulsating DC. Depending on the machine, this pulsating DC can be present in either a "half-wave" machine or a "full-wave" machine.

3. To calculate the number of impulses present in a given X-ray exposure, one must know the time of exposure and the type of machine (full or half-wave).

EXAMPLE: For a full-wave machine on an exposure lasting one-fourth second, how many impulses are used? On a full-wave machine 120 impulses would be present in a second, so 120 X 1/4 equals 30. The answer is 30.

EXAMPLE: For a half-wave machine on an exposure lasting 1/6 second, how many impulses are used? On a half-wave machine 60 impulses would be present in one second, so we multiply 60 X 1/6. The answer is 10.

MEMORY WHEEL:



F. Questions from Students

G. Make Assignment - TM 8-280, pp 4-1 through 4-3, para 4-3 through 4-7

III. SUMMARY (5 min)

A. Review of Main Points

1. Voltage
2. Current
3. Resistance
4. Ohm's Law
5. Series and parallel circuits
6. Direct and alternating currents
7. Impulse-Time Relationship

B. Closing Statement: The understanding of what kilovoltage and milliamperage actually are is essential for the X-ray specialist to properly know the effects of changing each of these factors on the film. Since the X-ray machine is powered by AC and since the timing of most X-ray exposures is taken from the alternations of AC, an understanding of the relationship of AC waveform and its time relationship is also very important.

ACADEMY OF HEALTH SCIENCES *IM 38-520-021
MEDICINE AND SURGERY DIVISION 018
X-RAY BRANCH

Electricity: Ohm's Law, AC and DC

In order to fully understand proper exposure technique, the specialist must understand what happens inside of the X-ray machine when he manipulates the outside control knobs. The first stepping-stone to comprehension of this knowledge is an understanding of the different types of current used to operate the machine. Several weeks ago, we had a two-hour discussion on the basic principles of electricity. We are going to review those principles so that we can build from that point to new concepts of electricity.

Any science is based on categorization and measurement. Electricity is no exception. Electrical factors may be categorized according to the following basic factor - voltage, current and resistance.

Voltage is the pressure of "push" which makes electricity move. Voltage is obtained from the separation of positive and negative charges. The greater the number of charges separated, the greater is the voltage, or "push," that is produced on the electrons. Voltage is also termed electromotive force (emf), potential, or potential difference referring to potential energy of separated positive and negative charges.

The unit of measurement of voltage is the volt, and the instrument which is used to measure the amount of voltage is the voltmeter. A kilovolt is a unit of measurement of voltage just 1,000 times as large as the volt.

Electrical current is a flow of charged particles. In most familiar electrical devices, the charged particles are electrons and electrons alone. Except for the flow of current through gases and liquids, positively charged ions do not move to produce an electric current flow.

The unit of measurement of the current is the ampere, and the instrument used to measure the amount of current is the ammeter. The ampere is numerically equal to a rate of flow of approximately 6,300 quadrillion electrons passing a point per second. The ampere is a rate of electron flow and does not measure the quantity. The milliampere is a rate of electron flow equivalent to 1/1,000 ampere.

Electrical resistance is the property that all materials have in hindering or restricting the flow of electrons. The unit of measurement of resistance is the ohm. The amount of electrical resistance is dependent upon several factors. The type of conductor is highly important

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*This instructor's manuscript supersedes IM 38-520-019, 034

to the amount of electrical resistance. Some materials will allow an electric current to pass with great ease, while others will permit a current to flow only under excessive electrical pressures. In general, the metals are good conductors of electricity, while the nonmetals are poor conductors of electricity.

The dimensions of a material also greatly affect the flow of current through it. A long conductor, for example, has more atoms to hinder the flow so the current finds more hinderance or resistance than in a short conductor. A thick wire allows electrons to spread out more and allows a current to flow much more easily than a thin one. One other factor will influence electrical resistance but to only a small degree for most substances - this is temperature. In general, an increase in temperature will slightly increase electrical resistance, but this is not true of all substances.

The voltage, current, and resistance are related. We need to understand this relationship to understand the operation of the X-ray tube.

Briefly, let us review the three basic elements of electricity. Voltage is the electrical pressure which causes the electrons to move. Current is the rate of flow of electrons. Resistance is the hindering tendency which holds down the flow of electrons.

These three factors have a definite relationship with each other. This relationship was discovered and formulated into a mathematical formula by a man named Ohm. This relationship is called Ohm's Law.

Note that the letters E, I, and R are used to represent voltage, current, and resistance, respectively. These letters should be learned since most electrical terminology uses them in the mathematical manipulation of these electrical factors. Note that I stands for current measured in amperes, E for voltage measured in volts, and R for resistance measured in ohms.

Formulas and memory device - there are three forms of Ohm's Law.

$$I = \frac{E}{R} \quad R = \frac{E}{I} \quad E = I \times R$$

All three of these forms can be derived from the magic square memory device; simply cover the unknown factor and the necessary operation to be performed is shown:

$$\boxed{\frac{E}{I \times R}}$$

An understanding of Ohm's Law will help the student to understand the functions of variable resistance, choke coils, transformers, etc., which are used in the X-ray machine.

Since alternating current is used in the X-ray machine in such devices as the transformers, autotransformers, choke coil, and rectifiers and since the current determines the kind of X-rays that are produced, an understanding of this AC will enable specialists to better know the characteristics and abilities of the machine they will use. To gain this understanding, we will study the waveform and theory of alternating current.

Direct current is basically different from alternating current. Direct current is composed of electrons all traveling in the same direction. Direct current is of two types - uniform direct current and pulsating direct current. Uniform direct current is one in which the electron flow is smooth with no increases or decreases of speed. A pulsating direct current is characterized by a change of flow of the electrons.

Alternating current consists of flowing electrons which are alternating or changing directions and speed.

The wavelengths of an AC cycle is the distance from one point on the sine wave to the next identical point. The cycle is composed of two changes of direction of the electron flow. Each change of direction is called a pulsation, an impulse, or an alternation. Thus, there are two impulses for each cycle.

In the United States the alternating current is usually standardized to 60 cycles per second. That is, the generators which produce the electricity are very accurately controlled to produce 120 impulses per second. Because of the accuracy of the AC, we can use these pulsations of electric current in timing our X-ray exposure. Essentially, an electric clock does the same thing. An easy-to-use formula for changing time in seconds to impulses of alternating current is: impulses = S x 120. A "magic square" which will enable a derivation of either seconds of exposure or number of impulses formulas is:

$$\boxed{\frac{\text{impulses}}{S \times 120}}$$

To use this magic square, cover up the unknown factor and perform the indicated arithmetic.

The understanding of what kilovoltage and milliamperage actually are is essential for the X-ray specialist to properly know the effects of changing each of these factors on the film. Since the X-ray machine is powered by AC and since the timing of most X-ray exposures is taken from the alternations of AC, an understanding of the relationship of AC waveform and its time relationship is also very important.

ACADEMY OF HEALTH SCIENCES *LP 38-520-022
MEDICINE AND SURGERY DIVISION 018
X-RAY BRANCH

Magnetism and Electromagnetism (2 hours)

COURSES PRESENTED TO: 313-91P10, X-Ray Specialist

PLACE: Classroom

REFERENCES:

TM 8-280
Selman, Joseph. The Fundamentals of X-Ray and Radium Physics. 5th ed. Springfield, Illinois: Charles C. Thomas, Publisher, 1972, pp 84-102 132-133.

STUDY ASSIGNMENT: Before class, read TM 8-280, pp 4-5 through 4-9, para 4-9 through 4-20.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 and GR 38-520-001-C

TOOLS, EQUIPMENT, AND MATERIALS: None

PERSONNEL: One instructor, 91P2H/91P3H/91P4H

INSTRUCTIONAL AIDS: Chalk, chalkboard, eraser; overhead projector, screen; magnets, electromagnets, transformer, batteries, wire, ammeter, iron filings, compass.

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Lecture

FIRST HOUR

I. INTRODUCTION (5 min)

A. Opening Statement: Almost everyone knows that magnets will pick up pins, nails, etc. It is less commonly realized that magnetism and electricity are inseparably connected. Many devices used in the X-ray machine depend upon this interrelationship of electricity and magnetism.

B. Objectives

1. Name one electromagnetic device which operates using the following electromagnetic induction principles:

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*This lesson plan supersedes LP 38-520-018, 082.

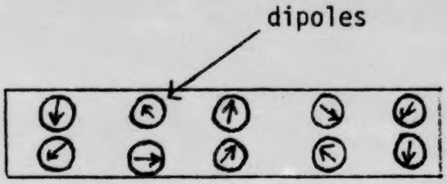
        - a. Relative motion
        - b. Mutual induction
        - c. Self-induction
    - 2. Define: Electromagnetism, electromagnetic induction
    - 3. State the fundamental law of magnetism
    - 4. State the electromagnetic principle involved and its function for each of the following devices:
        - a. Generator
        - b. Choke coil
        - c. Relay (contactor)
        - d. Transformer
        - e. Autotransformer
- C. Class Procedure and Lesson Tie-in: None

II. EXPLANATION (80 min)

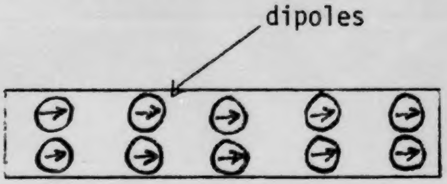
NOTE: Students using GR 38-520-001-1C have major headings filled in and must complete their notes as per outline.

- A. Magnetism
    - 1. Definition - the natural property of certain materials to align themselves in a North-South direction
    - 2. History
        - a. Magnesia - (ancient Greece) first compasses made
        - b. China - navigators used compasses
        - c. Europe
        - d. Oersted (Denmark - 1819) first electromagnet
    - 3. Magnetic theory
        - a. Atomic alignment - each atom has an associated magnetic field. The term, dipole, is used to describe this concept

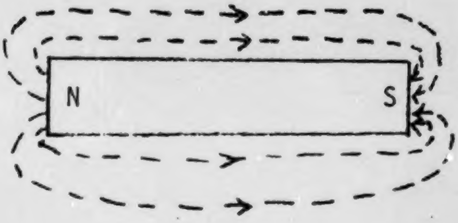
Non-magnetic substance
(non-alignment of dipoles)

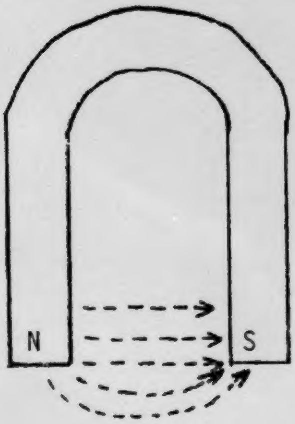


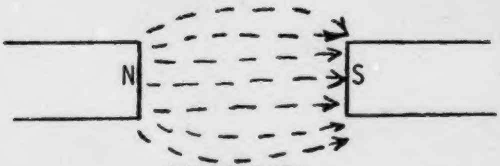
Magnetic substance
(alignment of dipoles)



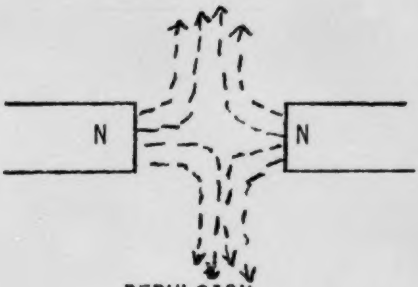
b. Fields (flux lines) - invisible lines of force that flow (it is assumed) from North to South







ATTRACTION



REPULSION

4. Types of magnetism

   a. Natural - lodestone, magnetite

   b. Artificial - man-made (ALNICO)

   c. Electromagnetism

547

5. Characteristics

   a. Permeability - the ease with which a material is magnetized.

   b. Retentivity - how long a material remains magnetized

6. Laws of magnetism

   a. Every magnet has a North and a South pole.

   b. Fundamental law of magnetism

      (1) Like poles repel

      (2) Unlike poles attract

   c. The force of attraction (or repulsion) varies directly with the strength of the fields and inversely with the square of the distance between them

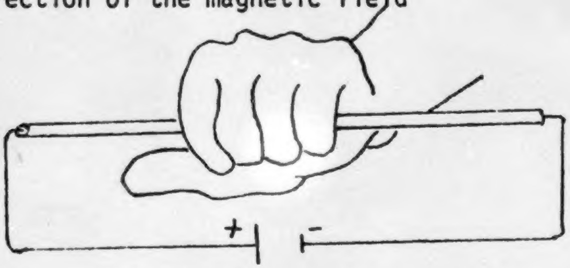
B. Electromagnetism

1. Definition - the process of producing magnetism by the use of electricity

2. Theory

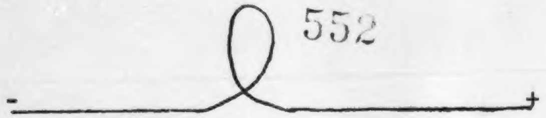
   a. Current in a straight wire produces a magnetic field which exists only as long as the current flows

   b. Left-hand thumb rule - when the thumb of the left hand points in the direction of electron flow, the fingers designate the direction of the magnetic field



3. Current in a Helix (coil)

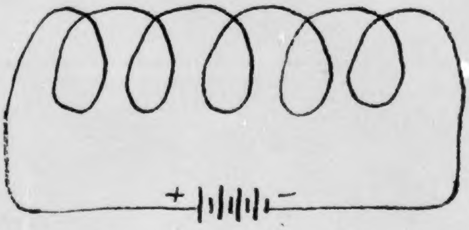
   We can increase the magnetic field surrounding a conductor by coiling the wire



552

The more coils, the stronger the field

NOTE: In the timer circuit of the X-ray machine, a device that operates on the principle of electromagnetism is the RELAY (or CONTACTOR). The RELAY serves as a kind of remote control switch by completing a high voltage circuit when a small voltage and current is passed through a small coil creating a magnetic field.



In addition, an iron core would concentrate the magnetic field in the part of the coil into which it is inserted

C. Electromagnetic Induction

1. Definition - the process by which electricity is produced by the use of magnetism

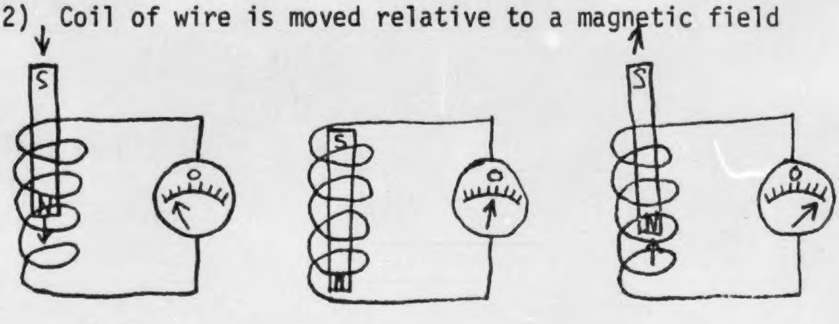
2. Principle - when a wire that is part of a closed circuit is moved through a magnetic field (or vice versa), a current is induced in the wire

3. Types

   a. Relative Motion Principle - used in generator (a commonly used device for producing large quantities of voltage and current)

      (1) Magnetic field is moved relative to a coil of wire, or

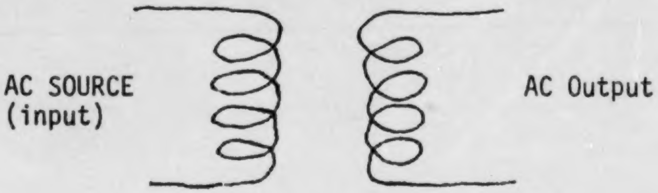
      (2) Coil of wire is moved relative to a magnetic field



(In the diagrams above, the magnetic field is being moved relative to the coil of wire.)

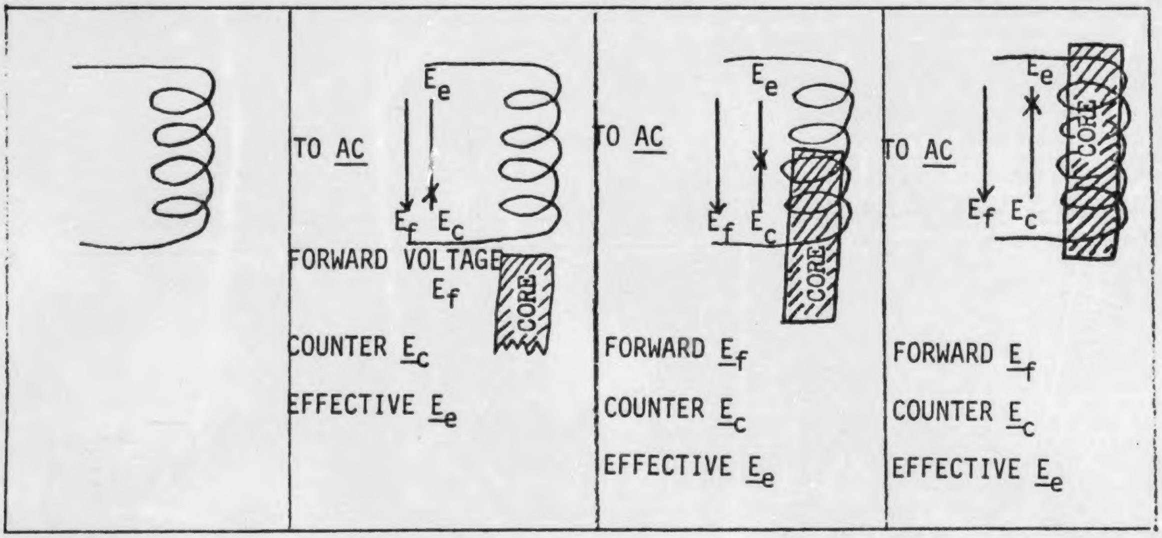
b. Mutual Induction Principle - used in transformers (AC devices used to change an input voltage and current to a different output voltage and current)

(1) AC input creates a changing magnetic field around the first coil


AC SOURCE
(input)
AC Output

(2) The expanding and contracting field "cuts across" the second coil inducing a voltage

c. Self Induction Principle - used in choke coil and autotransformer. The choke coil is used as a filament current selector and the autotransformer is used as a voltage selector


TO AC
E_e
E_f
E_c
FORWARD VOLTAGE
E_f
CORE
COUNTER E_c
EFFECTIVE E_e
TO AC
E_e
E_f
E_c
CORE
FORWARD E_f
COUNTER E_c
EFFECTIVE E_e
TO AC
E_e
E_f
E_c
CORE
FORWARD E_f
COUNTER E_c
EFFECTIVE E_e

Self-induction occurs when a core is inserted effectively reducing the passage of current through a coil. This concentration of electrons is called BACKVOLTAGE (or COUNTERVOLTAGE)

D. Questions from Students

E. Make Study Assignment - TM 8-280, pp 4-5 through 4-9, para 4-9 through 4-20

550

III. SUMMARY (5 min)

A. Review of Main Points

1. Magnetism

2. Electromagnetism

3. Electromagnetic induction

B. Closing Statement: The theory of magnetism and electromagnetism forms the basis for many electronic devices which are moulding our life styles today. The X-ray machine, itself, uses many internal devices which operate solely on the theories discussed in this block of instruction. We will build on these theories and discuss some of the more important electronic devices found in the X-ray machine circuits later this week.

ACADEMY OF HEALTH SCIENCES *IM 38-520-022
MEDICINE AND SURGERY DIVISION 018
X-RAY BRANCH

Magnetism and Electromagnetism

Almost everyone knows that magnets will pick up pins, nails, etc. It is less commonly realized that magnetism and electricity are inseparably connected. Many devices used in the X-ray machine depend upon this interrelationship of electricity and magnetism.

There is a relationship which exists between electricity and magnetism. An understanding of this relationship will enable the X-ray specialist to do a better job because of increased understanding of the nature of electricity.

It has long been known that magnets will attract small bits of iron. The earliest magnets were, of course, natural magnets of iron ore and were called lodestones.

It was also early noted that a magnet which is freely suspended will point in a North-South direction. This effect is the basis of our modern compass. This was about the extent of our understanding of magnets until the first part of the 19th Century.

In 1819 Hans Christian Oersted noticed that a current flowing through a wire could deflect a compass needle. By experimentation, he proved that there was a definite link between electricity and magnetism.

It has been shown that every moving electron (or any moving charged particle) has a magnetic field which acts perpendicular to the direction of electron motion. Since moving electrons are a major constituent of all atoms, it might be conjectured that each atom would be a miniature magnet. This, however, is for most atoms, a false conclusion. In most atoms, the electron rotation is such that the magnetic field of each electron is balanced by the opposing fields of other electrons.

Iron, and to a lesser extent nickel and cobalt, have electrons which rotate in such a way that their fields are greater in one direction than in the others. Thus, each atom of these elements are, in effect, tiny magnets.

Most iron is not naturally magnetic in spite of the fact that the individual atoms are. This is due to the fact that the magnetized atoms are jumbled in all directions and the magnetism from one atom is neutralized by the randomly jumbled situation of the other atoms. If, however, all the atoms are lined up in one direction, the whole piece of iron becomes magnetized. This phenomenon is known as dipole alighment.

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*This instructor's manuscript supersedes IM 38-520-018, 082.

552

Materials which can be magnetized have certain characteristics which explain their properties. Permeability describes how hard it is for a material to become magnetized (align dipoles). The higher the permeability, the more energy is needed to cause a material to align its dipoles. Retentivity describes how long a material will stay magnetized once the dipoles have been aligned.

Several laws govern the behavior of magnets. First, we find that every magnet must have a North and a South pole. A second law is very similar to the law of electrostatics. This law talked about charges (+ or -). With magnets, we have poles (N or S). The law states that like poles repel and unlike poles attract. The last law we will discuss speaks of the force of either attraction or repulsion, stating that this force varies directly with the strength of the fields and inversely with the distance between the fields. This simply says that the greater the field, the stronger the force, and the farther away these fields, the smaller the force of attraction or repulsion.

The relationship between magnetism and electromagnetism is the factor which has paved the way for our civilization of today. When a current is flowing in a straight wire, a magnetic field exists about the wire. It can be shown that this field is in the form of concentric circles about the wire. A compass brought near the wire will be deflected perpendicularly to the wire. The needle will point in one direction if held above the wire and the other direction if held below the wire. This indicates that there is a direction of action of this magnetic field. In fact, if the current is changed in direction in the wire, the magnetic field direction is changed too, as is shown by the magnet changing its direction. It will be found that any flow of electricity will produce these lines of magnetic force. This phenomenon is called electromagnetism.

The strength of the magnetic field varies directly with the current in the wire and inversely as the square of the distance from the wire. When a wire is coiled into a helix, the lines of force from each turn unite with those of the other turns increasing the strength and effectiveness of the field. The resultant field is similar in shape to that of a permanent magnet. Since the coil derives magnetism from electricity, such a coil (solenoid) is called an electromagnet.

Adding a soft iron core to the coil greatly increases the strength of the electromagnet. Iron tends to concentrate or "pull in" magnetic lines of force which would otherwise be farther apart and thus be weaker.

When magnetic lines of force pass through a conductor of electricity, a voltage is formed. If the wire forms a complete circuit, a current will be pushed by this voltage. This is true, however, only during the time that the lines of force which would otherwise be farther apart and thus be weaker.

There are three methods of producing a current by electromagnetic induction: (1) relative motion, (2) mutual induction, and (3) self-induction.

The relative motion type of electromagnetic induction exists when a magnet moves past a wire or when a wire moves past a magnet. In either case, a current will flow in the wire providing a complete circuit is available. This is the principle involved in the operation of a generator.

The following sentences describe mutual induction. When changing direct current or an alternating current flow in a circuit, magnetic lines of force are continually expanding and collapsing about the wire. When another circuit is nearby (but not connected), the magnetic lines of force from the first circuit cut through the second inducing a current to flow in the second circuit. Since the magnetic lines are constantly changing direction, the resultant current will also change direction and an alternating current is then produced. This is the principle of the transformer which will be discussed in the next block of instruction.

Next, self-induction will be discussed. When a current changes its rate or direction of flow through a coil of wire, the resulting magnetic lines of force cut through the other turns of wire causing a voltage to be induced in a direction opposite to the applied voltage. This reduces the effectiveness of the applied voltage and the current which can flow will then be smaller. This induced opposing voltage is called counter emf or back electromotive force.

The choke coil is based on this principle. The choke coil consists of a coil of wire witn an adjustable iron core. The iron core may be inserted into the coil to different degrees, thus, changing the amount of back emf and the amount of current which can flow. The choke coil is used to regulate currents and voltages.

The theory of magnetism and electromagnetism forms the basis for many electronic devices which are moulding our life styles today. The X-ray machine, itself, uses many internal devices which operate solely on the theories discussed in this block of instruction. We will build on these theories and discuss some of the more important electronic devices found in the X-ray machine circuits later this week.

ACADEMY OF HEALTH SCIENCES *LP 38-520-023
MEDICINE AND SURGERY DIVISION 028
X-RAY BRANCH

Transformers and Autotransformers (2 hours)

COURSES PRESENTED TO: 313-91P10, X-Ray Specialist

PLACE: Classroom

REFERENCES:

TM 8-280
Selman, Joseph. The Fundamentals of X-ray and Radium Physics. 5th ed. Springfield, Illinois: Charles C. Thomas, Publisher, 1972, pp 120 - 129.

STUDY ASSIGNMENT: Study TM 8-280, pp 4-13 through 4-16, para 4-27 through 4-30.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280, GR 38-520-001-1C

TOOLS, EQUIPMENT, AND MATERIALS: Not applicable

PERSONNEL: One instructor, 91P2H/91P3H/91P4H

INSTRUCTIONAL AIDS: Chalk, chalkboard, and eraser; demonstration transformer; autotransformer.

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Lecture

FIRST HOUR

I. INTRODUCTION (5 min)

A. Opening Statement: Our electrical achievements in everyday life are due in a large part to the development of transformers. Transformers permit long-distance transmission of power. They are used in the X-ray machine to boost voltages or currents. They are responsible for producing kilovoltage and milliamperage.

B. Objectives

1. List the two types of transformers.

2. List the components which comprise the transformer and autotransformer.

This lesson plan supersedes LP 38-520-023, 087.

3. State the principles of electromagnetic induction used in the transformer and autotransformer.

4. State the functions of the step-up transformer and autotransformer.

5. Define transformer.

6. Describe the operation of the transformer.

7. Describe the difference in construction of the step-up and step-down transformer.

8. Calculate the primary (or secondary) voltage and current when given the transformer ratio and the secondary (or primary) voltage and current.

C. Class Procedure and Lesson Tie-in: None

II. EXPLANATION (80 min)

A. Transformer

1. Definition - a device which changes an alternating current of one voltage and current into another alternating current with a different voltage and current.

2. Construction

    a. Primary winding

    b. Secondary winding

    c. Iron core

3. Operation

QUESTION: In mutual induction, what type of current flow is required?

ANSWER: AC characteristic flow.

    a. Principle involved - mutual induction

    b. Alternating lines of force

    c. Alternating current produced in secondary

4. Efficiency

    a. Up to 99 percent

b. Reasons for loss

(1) Copper losses

(2) Eddy current losses

(3) Hysteresis losses

5. Power relationship

a. Formula - $P = E \times I$

b. Effect - voltage increase causes current decrease

6. Types of transformers

a. Step-up - sketch

(1) Construction - more windings on secondary

(2) Voltage - increases in output

(3) Current - decreases in output

b. Step-down - sketch

(1) Construction - more windings on primary

(2) Voltage - decreases in output

QUESTION: From the power relationship, if voltage decreases in the output, what will happen to current?

ANSWER: Current increases in output.

(3) Current - increases in output

7. Formula

a. Turns ratio

b. Equation: $\frac{T_p}{T_s} = \frac{E_p}{E_s} = \frac{I_s}{I_p}$

c. Examples

QUESTION: To find the turns ratio, do you have to know the turns in the primary and the turns in the secondary?

ANSWER: No. Knowing both voltages or both currents will also give the turns ratio.

8. Things to note

a. Windings versus voltage

b. Voltage versus current

B. Autotransformers

1. Definition - an AC device used as a voltage selector

2. Construction - sketch

a. Single coil

b. Iron core

c. Major selector switch

d. Minor selector switch

e. Line voltage compensator

QUESTION: By looking at a diagram of an autotransformer, how do you distinguish between the major and minor selector switches?

ANSWER: Noting the number of turns between the taps on the switches. The major selector switch will have more space between taps, thus, more turns.

3. Operation - self-induction

NOTE: Transformer laws apply.

C. Questions from Students

III. SUMMARY (5 min)

A. Review of Main Points

1. Transformer construction and operation

2. Types of transformers

3. Transformer formula - turns ratio

3. Autotransformer construction and operation

B. Closing Statement: You have just learned two of the most important devices within the X-ray machine circuit. Transformers and autotransformers are vital to all types of complex electronic circuitry. A basic understanding of these components will be a valuable tool for jobs to come.

ACADEMY OF HEALTH SCIENCES
MEDICINE AND SURGERY DIVISION
X-RAY BRANCH

*IM 38-520-023
028

Transformers and Autotransformers

Our electrical achievements in everyday life are due in a large part to the development of transformers. Transformers permit long-distance transmission of power. They are used in the X-ray machine to boost voltages or currents. They are responsible for producing kilovoltage and milliamperage. As an X-ray technician, you must be familiar with the functions of transformers and autotransformers in an X-ray machine in order to select the proper amount of voltage for each exposure.

This period we are going to study the purpose, construction, components, laws, and uses of transformers. The understanding of these devices helps greatly in understanding the way X-rays are made and the characteristics of the X-rays which are produced. Therefore, the technician should have a basic idea of how transformers work to enable him to know the proper adjustments to make on his X-ray machine to produce the type of X-rays which are required.

A transformer is a device which changes an alternating current of one voltage and current into another alternating current of a different voltage and current.

The transformer consists of two coils of wire. The first coil, into which the initial current is sent, is called the primary winding. The second coil, from which the new current is obtained, is called the secondary winding. There is no electrical connection between these windings, but they are usually wrapped around an iron core. When these coils are wrapped on opposite sides of a square "ring," a doughnut-type of transformer is formed. The iron core has the purpose of concentrating the magnetic lines of force which are produced by the electricity and increasing their effectiveness in the transformer operation.

An alternating current in the primary winding causes a magnetic field to be set up. This field expands and collapses, changing its direction of action as the alternating current changes its speed and direction. The iron core of the transformer concentrates the magnetic lines of force, causing a greater number to sweep through the windings on the secondary side of the transformer. When these lines of force cut through the secondary coil, a voltage is induced across the coil. This voltage depends upon the direction of flow of current in the primary side, the amount of current and voltage applied to the primary side, and the number of windings on the primary and secondary side of the transformer.

No device is 100 percent efficient in transferring energy from one place to another, and the transformer is no exception. The transformer can be made up to about 99 percent efficient though. This is about as efficient as any device can be made.

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*This instructor's manuscript supersedes IM 38-520-023, 087.

There are several reasons for loss of efficiency in the transformer. The wire, itself, has a rather high electrical resistance due to the great length of the windings. Electricity flowing through this resistance produces heat which removes energy from the output of the transformer. This type of loss is termed "copper losses." A second source of energy loss is in the iron core. As magnetic lines of force cut through the core, little whirlpool-type currents called eddy currents are produced. These eddy currents heat the core. This heat loss of energy can be reduced by using electrically resistant silicon steel cores and making the cores of thin sheets. This is termed "lamination" of the core. The thin laminae resist the flow of eddy currents between them.

The third loss of energy is due to the magnetic properties of the iron core and is called "hysteresis." Each change of direction of the current causes corresponding changes in the magnetic dipoles within the core. This causes a constant shift of the atoms and molecules in the core causing heat. This, of course, reduces the energy output of the transformer.

Electrical power cannot be created or destroyed. Because of this, a transformer can never deliver more power than it receives. Due to the fact that the efficiency of the transformer is less than 100 percent, it actually will always deliver less power than is put into it. In our discussion of the power law, however, we are going to assume that the transformer is 100 percent efficient. Although this is not true, it is a simplification which greatly eases the problem of understanding transformers and is sufficiently accurate to understand the basic principles.

The measurement of electrical power is in units called watts. Power is formed by multiplying the voltage by the amperage or according to the formula P (watts) = E (volts) x I (amperes).

Assuming a 100 percent efficiency, the power input equals the power output; that is, $E_p \times I_p = E_s \times I_s$. Note that when the voltage is stepped up as in a step-up transformer, that the current is stepped down. When the voltage is stepped down, the current increases. This inverse relationship is always found between the voltage and current in a transformer.

EXAMPLE: If 100 volts, 3 amperes are applied to a 10:1 step-down transformer, the new voltage will be 11 and the new current will be 30 amperes.

$$E_p \times I_p = E_s \times I_s$$

$$110 \times 3 = 11 \times 30$$

There are two types of transformers. A step-up transformer will change a lower voltage input into a higher voltage output, while a step-down transformer changes a higher voltage input into a lower voltage output. A step-up transformer has more windings on the secondary side than on the primary side, while the step-down transformer is reversed. When the voltage is stepped up, the current is proportionally stepped down and vice versa.

The ratio of windings on the primary side as to the secondary side determines the change on the incoming voltage. The following formula determines the relationship between the ratio of turns of wire and the voltage changes.

$\frac{T_p}{T_s} = \frac{E_p}{E_s} = \frac{I_s}{I_p}$ where T_p is the number of turns of wire on the primary side, T_s is the number on the secondary side, E_p is the voltage on the primary side, E_s is the voltage on the secondary side. I_s is the current on the secondary side, and I_p is the current on the primary side. Notice that if the transformer has more windings on the secondary side than on the primary side that the voltage will be increased and a step-up transformer results.

For example - a transformer having 1,000 turns of wire on the primary side and 100 turns of wire on the secondary side is a 10:1 step-down transformer. If a voltage of 110 is applied to the primary winding, a voltage of 11 will be formed in the secondary winding. If there were 100 turns on the primary to 1,000 on the secondary, it would be 1:10 step-up transformer. An input of 110 volts to the primary would cause an output of 1,100 volts on the secondary side.

Common questions - according to Ohm's law, when the voltage is increased, the current also increases. Why is this not true in transformers? Ohm's law deals with only one circuit at a time. In the transformer, the primary winding and the secondary winding are separate circuits and Ohm's law does hold true within each circuit, but not between circuits.

Autotransformers obey the same laws as transformers, but their construction and function are different from regular transformers. The construction of the autotransformer is quite simple. It consists of a laminated iron core around which is wound a single winding of wire. This winding serves as both the primary and the secondary windings. On either end of the autotransformer are selector switches which can make electrical contact with selected turns of wire about the core. One of these selectors changes the number of turns by about 10, and selects a voltage change of from 7 to 10 volts. This is called the major selector switch. The other selector makes contact with each turn of wire so a change of one turn will produce a voltage change of from one to two volts. This selector switch is called the minor selector switch.

A similar device is used on the primary side of the autotransformer as a line voltage compensator. The line voltage compensator adjusts the number of windings used as a primary to compensate for changes of incoming voltage.

The purpose of the autotransformer is to select the voltage which is to be applied to the step-up transformer in the X-ray machine. The autotransformer then is a voltage selector. By means of the major and minor selector switches the number of windings used as the secondary side are charged. By this means, the autotransformer acts as a variable step-down transformer. By properly selecting the major and minor selector switch settings, the autotransformer can deliver almost any voltage desired from about 30 volts up to as much as 100 volts.

It will be noted that the autotransformer works on the same principle as the choke coil, that of self-induction. It is also easy to see that the autotransformer obeys the same laws with regard to winding ratio to voltage ratio as the transformer even though only a single winding is used.

You have just learned two of the most important devices within the X-ray machine circuit. Transformers and autotransformers are vital to all types of complex electronic circuitry. A basic understanding of these components will be a valuable tool for jobs to come.

ACADEMY OF HEALTH SCIENCES
MEDICINE AND SURGERY DIVISION
X-RAY BRANCH

*LP 38-520-024
038

Meters and Timers (2 hours)

COURSES PRESENTED TO: 313-91P10, X-Ray Specialist

PLACE; Classroom

REFERENCES:

TM 8-230
Selman, Joseph. The Fundamentals of X-Ray and Radium Physics. 5th ed. Springfield, Illinois: Charles C. Thomas, Publisher, 1972, pp 116-119.

STUDY ASSIGNMENT: Read TM 8-280, pp 4-12 through 4-13, para 4-26

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 and GR 38-520-001-1C

TOOLS, EQUIPMENT, AND MATERIALS: None

PERSONNEL: One instructor, 91P2H/91P3H/91P4H

INSTRUCTIONAL AIDS: Demonstration meter (combined galvanometer, ammeter, voltmeter), hand timer; chalk, chalkboard, and eraser

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Lecture

FIRST HOUR

I. INTRODUCTION (3 min)

A. Opening Statement: It is necessary to have a device for reassuring the amount of voltages and currents in order to know what values of these electrical factors are being used during an exposure. We are going to study the various types of meters and how to use them.

B. Objectives

1. State the purpose of the ammeter, voltmeter.

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*This lesson plan supersedes LP 38-520-021, 032.

2. State how the ammeter and voltmeter are connected into a circuit.

3. State the uses of the ammeter, milliammeter, and the milliampere-second meter.

C. Class Procedure and Lesson Tie-in

None.

II. EXPLANATION (40 min)

A. Methods of Measuring Current

1. Heat - undependable

2. Electrochemical - most accurate but unwieldy

3. Electromagnetism - widely used in meters

B. Galvanometer - Basic Meter

1. Components

a. Permanent magnetic - magnetic field

b. Rotating coil - in field

c. Zeroing spring - provides torque

d. Scale - indicates measurable values

e. Pointer - moves across scale

2. Theory of operation

C. Ammeter - Measures in Amperes

1. Galvanometer with low resistance shunt in parallel

2. High resistance shunt makes mA meter

3. Weight replaces spring - mAs meter or ballistic mA meter

4. Related use on X-ray machine

a. Ammeter - measures filament current flow

b. Milliammeter - measures current flow from cathode to anode

    c. MAS meter - measures current flow from cathode to anode during very short exposures (usually less than 1/5 second).

D. Voltmeter - Measures Voltage

    1. Galvanometer with high resistance in series

    2. "Measures" current-registers voltage

    3. Related use on X-ray machine

        a. Voltmeter - measures incoming line voltage

        b. Kilovoltmeter - measures potential across X-ray tube

E. Connecting Meters in Circuits

    1. Since a voltmeter measures the potential difference across any two points in an electric circuit, it must always be connected in parallel.

    2. An ammeter is used to measure all the current flowing in a (series) circuit. In that circuit the current flowing through all parts of the circuit is the same. The ammeter must therefore be connected in series in that circuit.

F. Questions from Students

III. SUMMARY (2 min)

A. Review of Main Points

    1. Galvanometer

    2. Ammeter

    3. Voltmeter

B. Closing Statement: These meters or their variations will be found on every X-ray machine. The student should understand what each meter reads to understand the final effect of their readings on the X-rays produced.

SECOND HOUR

I. INTRODUCTION (2 min)

A. Opening Statement: With today's high capacity X-ray machines, many exposures last a matter of a fraction of a second. The human reflexes are not fast enough to produce exposures of any accuracy in these short exposures. It is required, then, to have a device which can accurately terminate the exposure. Devices of this kind are called timers.

B. Objectives

1. List the six types of timers used in various X-ray machines.
2. State the reason that the electronic timer is a preferred type of timer.

C. Class Procedure and Lesson Tie-in

None

II. EXPLANATION (40 min)

A. Purpose of Timers

B. Types of Timers

1. Hand (mechanical) - least accurate
2. Synchronous
3. Impulse
4. Electronic - most accurate

C. Characteristics of Each Type

1. Hand - functions on a spring wound clock mechanism
    a. Minimum time - 1/8 of a second
    b. Time intervals - 1/8 of a second
    c. Maximum time - 12 to 20 seconds
    d. Things to note
        (1) When using, depress timer switch firmly
        (2) Count the number of clicks below one second (first click - "dead" click)
        (3) Never twist time dial backwards
        (4) Inaccurate below 3/8 of a second
        (5) Least accurate

2. Synchronous - functions on rotation of synchronous motor (counts cycles)
   - a. Short exposure range
     - (1) Minimum time - 1/20 of a second
     - (2) Time intervals - 1/20 of a second
     - (3) Maximum time - 9/10 of a second
   - b. Long exposure range
     - (1) Minimum time - 1 second
     - (2) Time intervals - 1/8 of a second
     - (3) Maximum time - 14 seconds

NOTE: Synchronous timers vary considerably from one manufacturer to another.

3. Impulse - functions same as synchronous, but starts and stops when exposure is at "0" potential (counts impulses)
   - a. Minimum time - 1/120 of a second
   - b. Time intervals - 1/120 of a second
   - c. Maximum time - 1/5 of a second

NOTE: Since maximum exposure time is so short, another timer (usually synchronous) is used on the same machine for longer exposures.

4. Electronic - when the exposure is started, a capacitor in the X-ray circuit simultaneously begins charging.

NOTE: Electronic timers are very accurate and have a wide range of time intervals.

   - a. Minimum time - 1 msec (1/1000 sec)
   - b. Time interval - 1 msec
   - c. Maximum time - infinite, although usually 12-15 sec

5. Milliampere-second - similar to electronic timer, X-ray tube current is used to charge a capacitor. Hence the mAs timer monitors the product of mA and time and terminates the exposure when the desired mAs is obtained
   - a. Minimum time - 1 msec

567

b. Usually designed to provide the highest safe tube current for the shortest time of exposure for any mAs selected

c. Since the mAs timer must monitor actual tube current, it is located on the secondary side of the step-up transformer

6. Phototimer - radiation transmitted through the patient is measured and exposure is stopped after the desired amount of radiation has reached the film.

   a. A manual timer should be used as a back-up timer in case the phototimer fails

   b. Currently used in mass chest surveys and fluoroscopy "spot" films

D. Questions from Students

NOTE: Read TM 8-280, pp 4-12 through 4-13, para 4-26.

III. SUMMARY (3 min)

A. Review of Basic Features of Each Type of Timer

B. Closing Statement: Of the many timer types, electronic, mAs, and phototimers will be found on the more modern equipment. Hand timers are usually restricted to small portable machines. As X-ray specialists, a knowledge of the various types of timers you will encounter is essential for a complete understanding of the X-ray machine.

572

ACADEMY OF HEALTH SCIENCES
MEDICINE AND SURGERY DIVISION
X-RAY BRANCH

*IM 38-520-024
038

Meters and Timers

It is necessary to have a device for reassuring the amount of voltages and currents in order to know what values of these electrical factors are being used during an exposure. We are going to study the various types of meters and how to use them.

There are several methods by which electric currents could be measured. The heat that is formed as a current which passes through a substance is dependent upon the quantity of current; but since heat is hard to contain, it is not a dependable way of measuring electric current.

When current passes through a salt solution, such as silver nitrate, an amount of metal (silver) is plated onto the negative electrode. This amount of metal is directly proportional to the current which flows. It is, however, quite difficult to accurately measure the exact amount of metal plated out and is unwieldy and thus impractical.

The most easily used principle is that of electromagnetism. It is on this principle that the galvanometer is based.

The galvanometer is the basic meter from which the others are adapted. The galvanometer is based on the principle that an electric current has associated with it a magnetic field whose strength is dependent upon the current which flows. This electromagnetism is caused to oppose the magnetic field of permanent magnets. This is achieved by placing a coil which rotates about a pivot between the poles of a permanent magnet. A spring coiled in a spiral causes the coil to maintain a zero position when no current is flowing. Attached to the coil is a pointer which moves across a calibrated scale when current is applied to the coil.

The ammeter is an adaptation of the galvanometer in which a low resistance called a shunt is shorted across the rotating coil. This causes a certain specified small percentage of the current to be measured by the coil with the remainder being shunted aside. The scale is calibrated to read directly the total quantity of current which flows.

The MA meter is basically the same as the ammeter except that the shunt is of a higher resistance and milliamperage is registered on the meter rather than amperage.

The MAS meter incorporates a small weight on the coil which gives it a moment of inertia, so that for very short exposures the coil will move indicating a current even after the current is stopped. This allows the current not to be indicated, but the product of the current and time of current flow. This product, MAS, gives a direct reading on this type of

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*This instructor's manuscript supersedes IM 38-520-021, 032.

meter. The MAS meter is also called a ballistic MAS meter. It is to be emphasized that the MAS meter is to be used for very short exposures only. Long exposures may damage the meter or at least given an off-the-scale reading.

The voltmeter is an adaptation of the galvanometer which has a high resistance connected in series with the coil. In this way, the total resistance of the coil and added resistance multiplied by the amperage which flows gives the voltage which impresses the current (reference is to Ohm's Law: E = I x R). The scale is calibrated to read directly in volts. A prereading meter may be calibrated to read, not the voltage actually measured, but that which will be formed.

These meters or their variations will be found on every X-ray machine. The specialist should understand what each meter reads to understand the final effect of their readings on the X-rays produced.

Timers which are found on X-ray machines will vary considerably from one manufacturer to another. To acquaint a person with all types of timers would be practically impossible. All types of timers can, however, be classified into four basic categories.

By knowing these basic categories, the student should be able to adapt to any type of machine with little trouble.

Timers are, of course, essential in the proper operation of the X-ray machine. In the earliest days of X-ray work, time of exposure was often in terms of minutes, while today exposures of 1/120 of a second are not only possible, but are often used. In a three-minute exposure, a matter of a few seconds either way would make little difference on a film; but with an exposure of 1/60 of a second, only one impulse (1/120 second) either way makes a difference of 50 percent in the exposure! An accurate means of determining this time of exposure becomes imperative.

The four types of timers, beginning with the least accurate and progressing to the most accurate and adaptable type are: hand or mechanical, synchronous, impulse, and the electronic timers.

The hand timer is essentially a spring wound clock mechanism which emits audible clicks of 1/8 second each during the exposure.

The synchronous timer depends upon the rotations of a synchronous motor to count the length of time of exposure. The synchronous timer is more accurate than the hand type.

The impulse timer also depends upon the rotations of a synchronous motor to measure the time, but has an added feature that the exposure will start and stop only during the "zero" positions of the alternating current, that is, between the impulses.

The electronic timer relies on the charging of a capacitor to terminate the exposure after a set amount of time.

The hand type of timer has a minimum exposure time of 1/8 of a second; but since this is very inaccurate, this short an exposure time should not be depended upon with this timer. Ordinarily, 3/8 of a second should be considered the shortest possible exposure time. Time intervals of 1/8 of a second are available and the maximum exposure is 12 seconds. In making exposures of less than one second, the number of clicks should be counted.

NOTE: There is one "dead" click at the beginning of the first second, so there are nine clicks in the first second; 1/2 of a second would be five clicks.

When using the hand timer, depress the timer button firmly, or the timer may run without an exposure being made. Never twist the timer indicator backward. This causes gears to be stripped and causes the timer to "creep" or run off time without making an exposure. Always run the timer off with the exposure button, but be careful never to make X-rays while doing so.

The synchronous timer may be in many forms. The type we have here at school will be the only one we will consider, however. The minimum exposure time is 1/20 of a second with 1/20-second time intervals up to 9/10 of a second for a short exposure range. For longer exposures, another range is provided. This range goes from a minimum exposure of one second in 1/8-second intervals up to about 14 seconds. It is to be noted that synchronous timers may be found which have only one range for both long and short exposures, but only one type is discussed here.

The impulse timer is more accurate than the synchronous timer and can use shorter exposure times. The minimum time is one impulse of 1/120 of a second, and time intervals are of course limited to individual impulses. The maximum exposure time is only about 1/5 of a second and in this lies the impulse timer's main objection. For exposures of longer than 1/5 of a second, another timer must be used. This other timer is usually a synchronous timer. If two timers are found on the same machine, they will be the impulse and synchronous timers.

The electronic timer is in widespread usage today. It is relatively simple and is accurate enough to replace many of its predecessors. When the exposure is started, a capacitor in the X-ray circuit begins charging. When the capacitor is fully charged, the circuit is opened and the exposure is terminated. There is an infinite possibility of time selections, but the shortest time can be as short as one millisecond. Time intervals can also be one msec with the maximum time usually being between 12-15 seconds, depending on the manufacturer.

Recent years have brought the development of the milliampere-second timer which is similar to the electronic timer, in that a capacitor is charged. However, since the mAs timer must monitor actual tube current, it is located on the secondary side of the step-up transformer. It is usually designed to provide the highest safe tube current for the shortest time of exposure for any mAs selected.

377

IM 38-520-024
038

Also, in recent years has been the development and improvement of the phototimer. The machine, through the use of a photoelectric cell or ionization chamber with its own fluorescent screen, amplifiers, and attendant relays, will sense the proper amount of radiation to the film and in turn terminate the exposure. In this way, the phototimer allows for patients of various sizes. In a larger patient it will be a longer period of time before the phototimer terminates the exposure; with a smaller patient, it will be a shorter period of time. While phototimers are reasonably reliable, a manual timer should always be used as a back-up timer in case the phototimer fails. Currently, phototimers are used in mass chest surveys and fluoroscopy "spot" films.

Of the many timer types, electronic, mAs, and phototimers will be found on the more modern equipment. Hand timers are usually restricted to small portable machines. As X-ray specialists, a knowledge of the various types of timers you will encounter is essential for a complete understanding of the X-ray machine.

572

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

Mr. John Mayes
*LP 38-520-020
016

Rectification (2 hours)

COURSES PRESENTED TO: 313-91P10, X-ray Specialist

PLACE: Classroom

REFERENCES:

TM 8-280, pp. 4-16 thru 4-20, para 4-31 thru 4-36.
Selman, Joseph. The Fundamentals of X-Ray and Radium Physics. 5th ed.Springfield, Illinois: Charles C. Thomas, Publisher, 1972. pp. 136-1466.

Study Assignment: TM 8-280 pp. 4-16 thru 4-20, para 4-31 thru 4-36

STUDENT UNIFORM AND EQUIPMENT: TM 8-280, GR 38-520-001-1C

TOOLS, EQUIPMENT AND MATERIALS: N/A

PERSONNEL: One instructor (91P2H, 91P4H).

INSTRUCTIONAL AIDS: Overhead projector, chalk, blackboard, eraser.

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Lecture

I. INTRODUCTION (5 min)

A. Opening Statement: There are many different types of X-Ray machines. Some are what we call full-wave rectified. Others may be self rectified or half-wave rectified. Understanding how these machines differ from one another is essential in order to determine the output on a given technique setting. As X-Ray Specialists you will be working with a greater variety of machines than the average technician. In order to effectively do this you must completely understand the differences in the rectifying systems.

B. Objectives

1. Define: Rectification, Valve Tube.

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*This lesson plan supersedes LP 38-520-020, 010

2. State:

    a. the three requirements for valve tube operation.
    b. the type of rectified current which results when using each of the following: self-rectified tubes, single-valve tube rectification, two-valve tube rectification, full-wave rectification.
    c. the uses of the Spin Top Test.

3. Convert (when given frequency of AC and type of rectification):

    a. impulses to seconds of exposure.
    b. seconds of exposure to impulses.

4. Perform mathematical computations (from memorized relationships) using the Spin Top Timer-Rectification test in any of the following situations:

    a. Given an exposure time, determine how many dots should be produced when using either full-wave or half-wave rectification in either the United States or overseas (four possible situations).
    b. Given the number od dots produced with a given mA value and a specified mode of rectification in a given geographical location, determine:

        1) the exposure time used.
        2) what mAs was produced.
        3) whether the timer was faulty and, if so, whether it runs too fast or too slowly.
        4) whether the rectification system is malfunctioning.
        5) whether a combination of 3 and 4 exists.

II. EXPLANATION (80 min)

A. Complete GR

NOTE: Refer to Annex A for print outline. (Students using GS 38-520-001-1 have major underlined headings filled in and must fill in their notes as per Annex A.)

574

B. Application of Spin Top Test

NOTE: Refer to Annex B for problems to be worked in class.

III. SUMMARY (5 min)

A. Review of Main Points.

1. Valve tube construction.

2. Types of rectification.

3. Spin Top Timer Test.

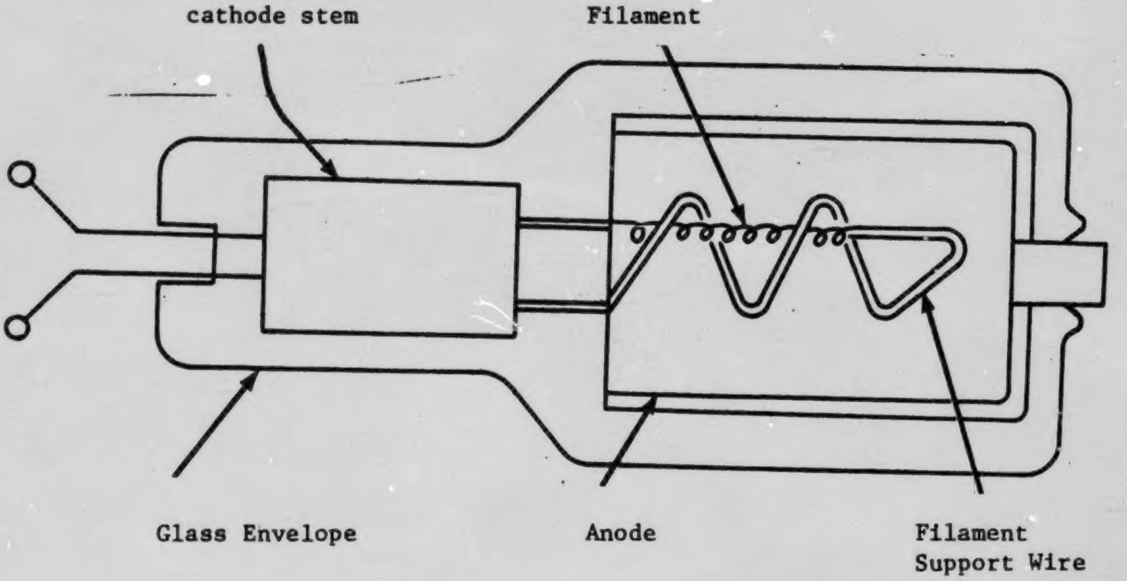
B. Closing Statement: An understanding of how electricity flows through the X-ray tube to produce X-rays, aids in the understanding of the rays which are produced. The effect of rectification on X-ray production should be thoroughly understood.

ANNEX A
RECTIFICATION

A. Rectification The process of changing AC to DC.

B. Valve Tube (Rectifier)

1. Construction


cathode stem
Filament
Glass Envelope
Anode
Filament Support Wire

2. Operating Conditions

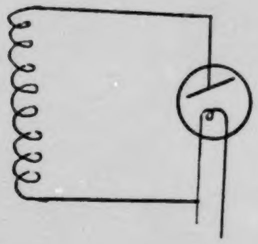
   a. Hot Filament
   b. Negative Cathode
   c. Positive Andoe

C. Types of Rectification

1. Half-wave

   a. Theory

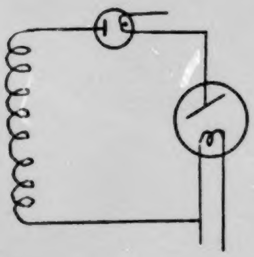
   The ½ cycle which is trying to go the wrong direction is held back (suppressed).



   b. Types

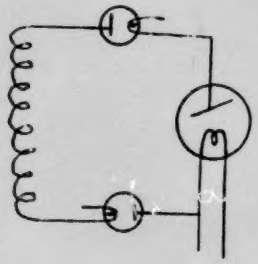
   (1) Self Rectification

   The X-ray tube itself is placed in series with the power source and resists the backward surge of current.



   (2) Single Valve-Rectification

   A single valve tube is placed in series with the X-ray tube and power source. This takes half of the rectifying lead from the X-ray tube.



   (3) Double Valve - Rectification

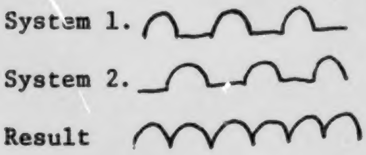
   A valve tube is placed on each side of the X-ray tube. The full rectifying load is removed from the X-ray tube.

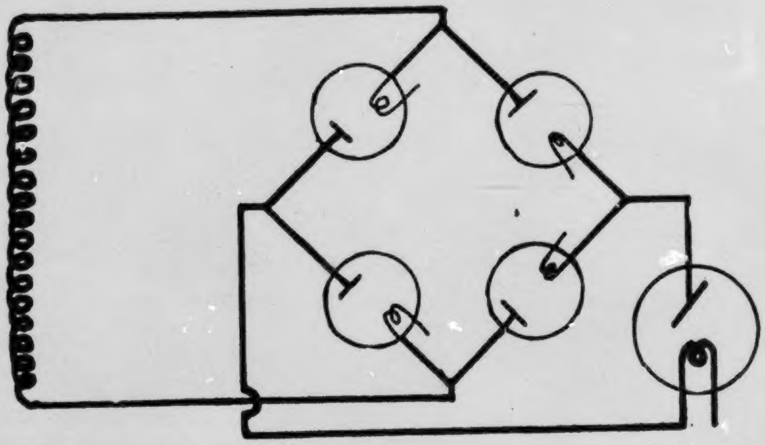
   HALF WAVE RECTIFICATION STILL RESULTS.

2. Full-wave

a. Theory Two half wave systems are hooked in parallel so that one system allows one AC impulse to be applied to the tube while the other system applies the next impulse to the tube.

b. Illustration

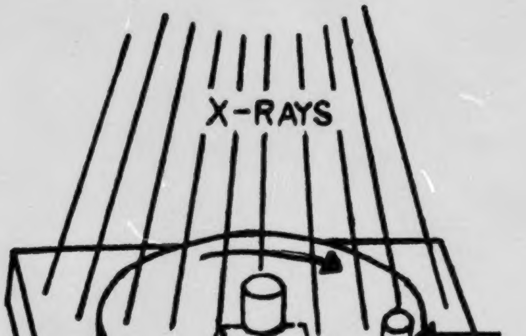




D. Spin-Top Timer Test

1. Construction

Spin Top



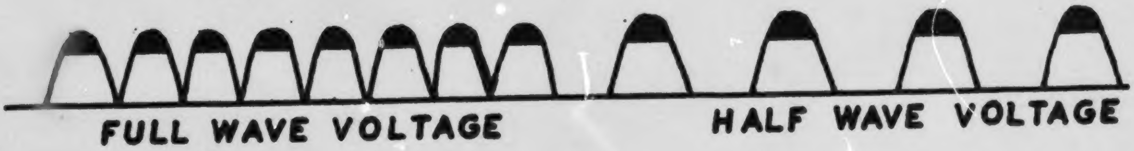
A disc which rotates about a pivot. The disc has a hole through which X-rays may pass.

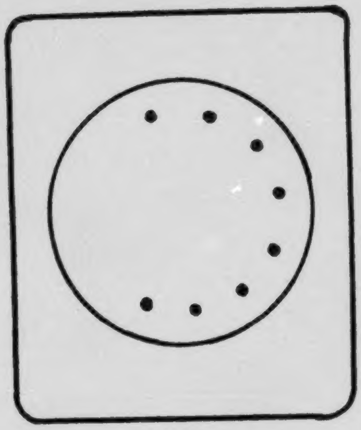
2. Application

   a. Spin wheel

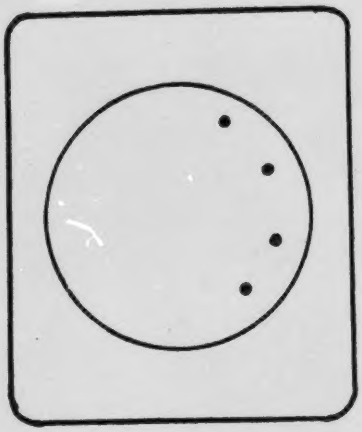
   b. Exposure of fixed time is set and made (usually <½ sec)

   c. X-rays pass through hole to film.
   Since X-rays come from the tube in distinct surges (at the center of each impulse) a dot is produced on the film for each impulse. The number of dots correspond exactly with the number of electrical impulses used during the exposure.





FULL WAVE
1/15 S, 8 DOTS
ON FILM



HALF WAVE.
1/15 S, 4 DOTS
ON FILM

ANNEX B

Problems:
Application of Spin Top Test

1. With an exposure of 1/5 second how many dots should be produced on a Spin Top Test when using:

   a. half wave rectification in Chicago.
   b. full wave rectification in Tokyo.
   c. half wave rectification in London.
   d. full wave rectification in San Antonio.

2. An exposure using 100 mA on the Spin Top Test produced 10 dots on the film. The full wave rectified machine was in El Paso, Texas.

   a. What exposure time was used?
   b. What mAs was used?
   c. If the timer has been set at 1/15 second to produce the 10 dots was the timer running too fast or too slow?

3. A Spin Top Test on a full wave rectified machine in New York City was run at 300 mA at .15 seconds. The resulting film showed 9 dots.

   a. How many dots should have been produced?
   b. What was most likely wrong to produce the 9 dots?
   c. What would probably have been wrong if 11 dots had been produced at .15 seconds exposure?

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DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

Mr. John Mayes
*IM 38-520-020
016

Rectification

There are many different types of X-ray machines. Some are what we call full-wave rectified. Others may be self-rectified or half-wave rectified. Understanding how these machines differ from one another is essential in order to determine the output on a given technique setting. As X-ray Specialists you will be working with a greater variety of machines than the average technician. In order to effectively do this you must completely understand the differences in the rectifying systems.

A rectifier can be classified as any device which will allow electricity to flow in one direction only. We could say that a rectifier either reroutes the positive phase of alternating current, making it flow in the same direction as the negative phase, or it may simply suppress this phase leaving only the negative phase flowing. This is determined by the hookup of the valve tube in the rectifier circuit. Whatever changes we make, we will always end up with current flowing in one direction. (D.C. Pulsating). However, if we suppress the positive phase of current we decrease the efficiency of the tube by one half because we have decreased the amount of current flow to the tube by an equal amount.

The most common and most efficient rectifying device is the valve tube. It's construction is similar to that of the X-ray tube. However, it is not capable of producing X-rays because of the alteration of certain key parts. A valve tube unlike an X-ray tube operates at a point well below the saturation current. Because of a superabundance of liberated electrons, the electrical resistance of such a tube is relatively small resulting in a very small voltage drop across the tube. It eliminates the factor of acceleration of filament electrons, which is essential for X-ray production. The electrons are liberated in a spherical direction. There is no focusing cup available to beam the electrons to the target, and the target is a large cylindrical cup which is many times larger than the target in an X-ray tube. The target is kept cool, thus electrons from the hot filament flow towards the cool target, but do not reach a high speed. All of these factors account for the lack of X-ray production in the valve tube.

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*This instructor's manuscript supersedes IM 38-520-020, 010

Self-rectification is the simplest type of rectification. Here the X-ray tube serves also as a rectifier or suppressor. Current can only flow through an X-ray tube in one direction, the same as in the valve tube. When the alternating current changes to the positive phase the current flow is in an anode to cathode relationship instead of a cathode to anode relationship. The tube cannot allow current flow in this direction because there are no liberated electrons at the anode. Therefore, this positive phase is suppressed by the X-ray tube. This positive phase is known as inverse voltage. If the inverse voltage is high enough it will heat the anode to the point where it releases electrons. These electrons will bombard the filament and cause damage to the tube.

In order to eliminate the chance of current flowing from the anode to the cathode, and also to reduce wear and tear on the X-ray tube, we employ a valve tube to absorb the impact of the inverse voltage. When using a valve tube in the circuit, the inverse voltage is stopped at the valve tube. Use of a valve tube does not increase the rate of impulses used, but it does allow a greater load to be placed on the tube than use of a self-rectified unit. Employment of a valve tube to act as an inverse suppressor is called half-wave rectification.

If four valve tubes are used even the positive phase of current can be utilized by rerouting it to the cathode side of the X-ray tube. In order to accomplish this the valve tubes work in pairs. Two valve tubes are responsible for directing the negative phase of current to the cathode. At any given time only two valve tubes will be functioning. By directing this positive phase which would otherwise be suppressed, we double the number of impulses used. This in turn doubles the output of the machine. This type of rectification is called full-wave rectification.

The simplest method of testing for competence of the valve tube is the spinning top method. The spin top is a flat metal top which has a small hole punched near one edge. It is placed on top of an X-ray film and is made to spin. An exposure is made while the top is in motion. The radiograph is developed and viewed to determine the number of dots or dark spots found on the film. Using a full-wave rectified unit there will be 120 impulses of current/sec., there should be 12 dots on the radiograph. If the number of dots is exactly half, this would indicate that one half the rectifying circuit was non-functional and the machine was operating on half-wave rectification. If the number of dots was 10, this might indicate that the timer was out of calibration.

582

In order to determine the number of impulses used at a given exposure you should use the following equations:

Full-wave rectified	# of impulses = Sec x 120
Half-wave rectified	# of impulses = Sec x 60

An understanding of how electricity flows through the X-ray tube to produce X-rays, aids in the understanding of the X-rays which are produced. The effect of rectification on X-ray production should be thoroughly understood.

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

Mr. John Mayes
*LP 38-520-023
016

X-Ray Machine Circuits (2 hours)

COURSES PRESENTED TO: 313-91P10, X-ray Specialist

PLACE: Classroom

REFERENCES:

TM 8-280,
Selman, Joseph. The Fundamentals of X-Ray and Radium Physics. 5th ed. Springfield, Illinois: Charles C. Thomas, Publisher, 1972, pp 228-255.

STUDY ASSIGNMENT: Before class read TM 8-280, 4-21 thru 4-26, para 4-37 thru 4-42.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280, GR 38-520-001-1 C

TOOLS, EQUIPMENT, AND MATERIALS: N/A

PERSONNEL: One instructor (91P2H or 91P4H)

INSTRUCTIONAL AIDS: Chart, "Basic X-Ray Circuit," chalk, chalkboard, and eraser; Transparencies (see Annex A).

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Lecture

I. INTRODUCTION (5 min)

A. Opening Statement: We have studied separately the parts which make up the X-ray machine and how each one works. Now we must put the parts together to see how the machine produces and controls the X-rays which are produced. At some time, it may become necessary for the Specialist to provide minor maintenance or repair to the X-ray machine; consequently, a knowledge of the basic circuit is necessary.

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*This lesson plan supersedes LP 38-520-023, 060

B. Objectives

Given a schematic diagram of a basic x-ray machine circuit (refer to page 205 of Physics GR) for reference:

a. Locate any specific component in the diagram when given its name or function.

b. Identify any indicated component in the diagram.

c. Specify the electrical function of any indicated component in the diagram.

d. Identify the sub-circuit of which any component is a member.

C. Class Procedure and Lesson Tie-in

None.

II. EXPLANATION (80 min)

NOTE: Refer to Annex B for printed outline. (Students using GR 38-520-001-1, 084 have major underlined headings filled in and must fill in their notes as per Annex B.)

III. SUMMARY (5 min)

A. Review of Main Points

1. mA circuit

2. kVp circuit

3. Timer circuit

B. Closing Statement: The importance of understanding the operation of the x-ray machine cannot be minimized. To really understand the control of X-Ray production the student must know the basic circuitry of the x-ray machine. An understanding of this curcuit will enable him to properly adjust his x-ray machine to compensate for factors which ordinarily are not on the technique chart but which may on occasion arise.

ANNEX A
INSTRUCTIONAL AIDS

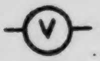
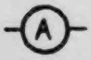
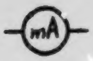
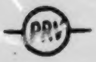
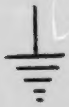
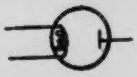
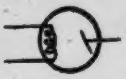
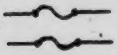
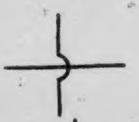
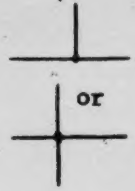
Transparencies

T 38-520-023-1	A transparency illustrating the components of the Milliampere circuit.
T 38-520-023-2	A transparency illustrating the components of the Timer circuit.
T 38-520-023-3	A transparency illustrating the components of the kVp circuit.
T 38-520-023-4	A transparency illustrating the entire X-ray machine circuit.

586

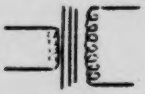
ANNEX B
X-RAY MACHINE CIRCUITS

A. Circuit Symbols

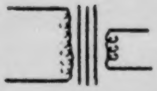
	Voltmeter (measures voltage)
	Ammeter (measures amperes) or current
	mA meter (measures tube current in mA)
	Prereading voltmeter (tells what voltage (kVp) will be produced upon exposure)
	Ground (Protects patient and technologist from shock)
	Valve Tube (Rectifies current-reduces load on X-ray tube)
	X-ray Tube (Produces X-rays)
	Power line with fuses (Protects whole machine from electrical overload)
	Crossed wires - not connected. (2 wires passing but not connected)
	Joined wires (Electrical connections)

591

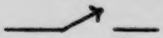
A. **Circuit Symbols** (continued)



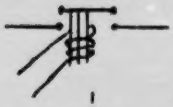
Step-up Transformer (steps up Voltage - current steps down)



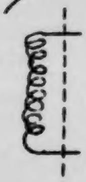
Step-down Transformer (steps down Voltage - current steps up)



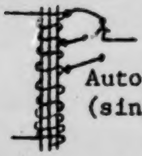
Switch (Turns off-on current in circuit)



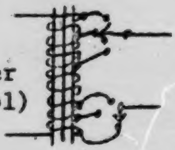
Contractor (Relay) (Remote control switch - small power turns on large power)



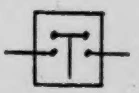
AC Source of Power (Secondary of power transformer) (Source of voltage at plug or fusebox)



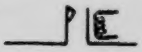
Autotransformer (single control)



Autotransformer (Double Control) (Selects kVp)

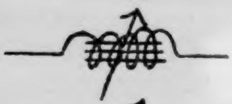


Timer (Times exposure)

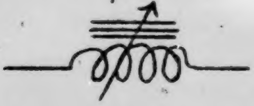


Circuit Breaker (Stops current flow if sudden surge of current occurs)

or



Choke Coil (Selects filament current - Selects mA)

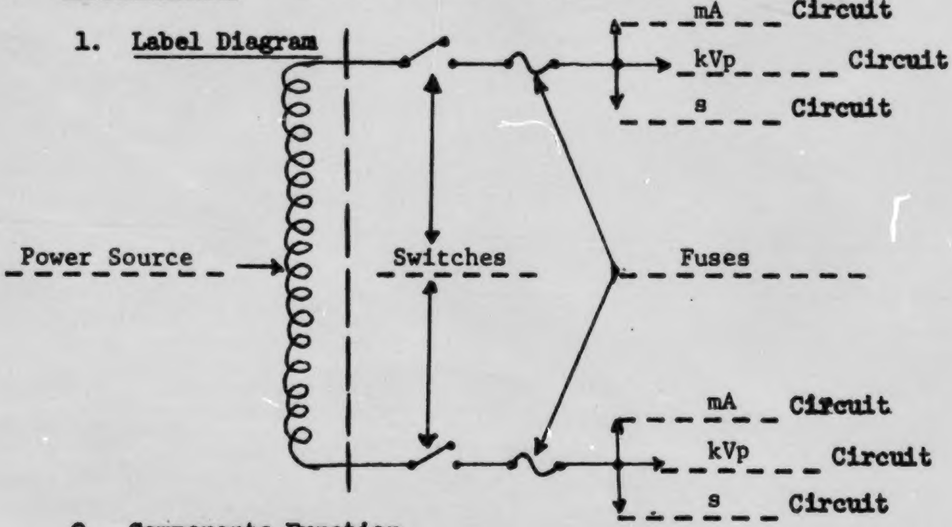


588

LP 38-520-023
016

B. **Power Source** Provides electrical power to whole machine.

1. **Label Diagram**


mA Circuit
kVp Circuit
s Circuit
Power Source
Switches
Fuses
mA Circuit
kVp Circuit
s Circuit

2. **Components Function**

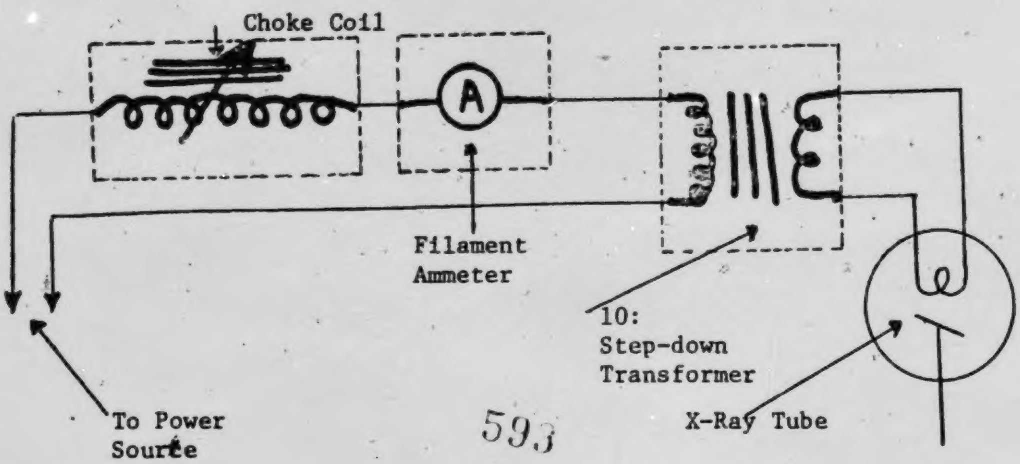
Provides electrical power to whole machine.

C. **Sub-Circuits**

1. mA - Circuit

a. **Function**
To regulate Filament heat and therefore mA.

b. **Draw Diagram and Label**


Choke Coil
A
Filament Ammeter
10: Step-down Transformer
X-Ray Tube
To Power Source

593

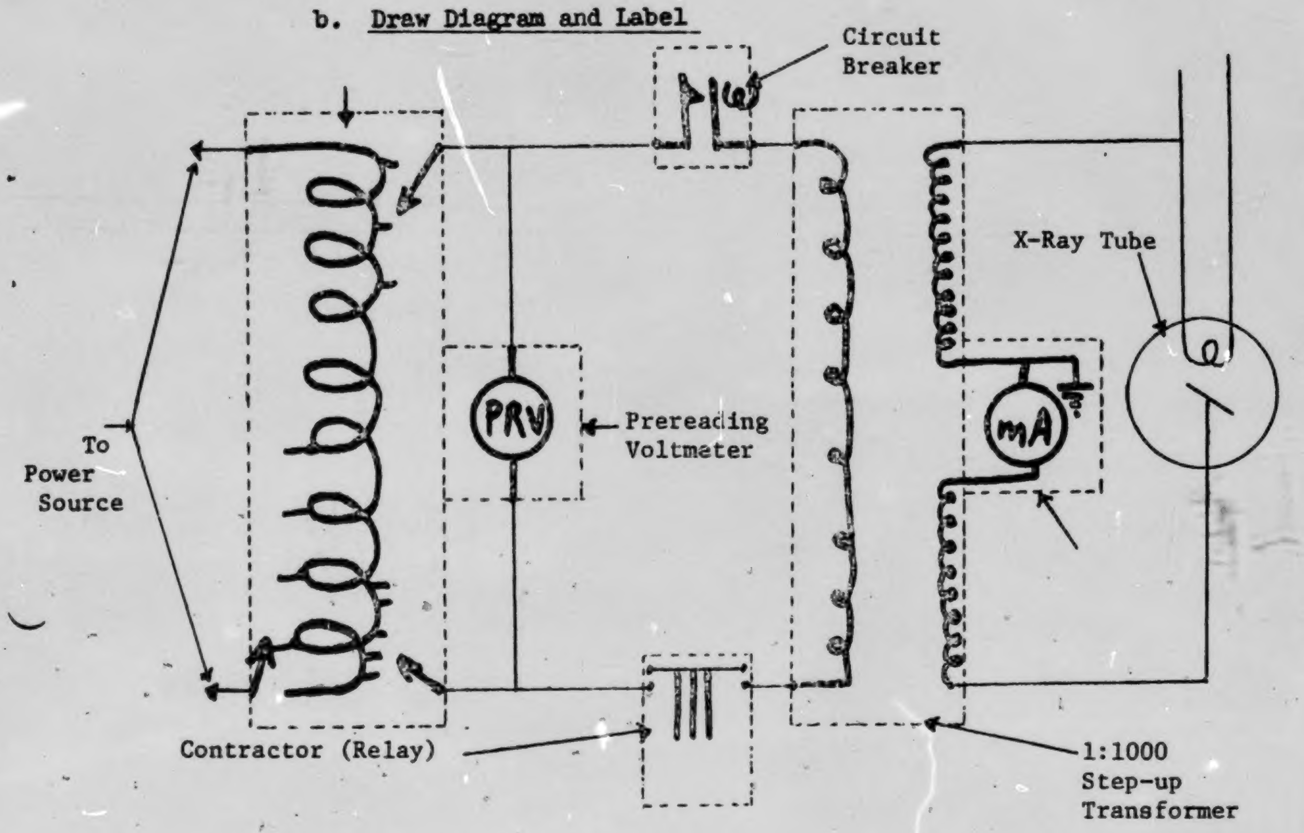
589

2. kVp - Circuit

a. **Function**

1. To select desired kVp
2. To boost voltage to kVp

b. **Draw Diagram and Label**

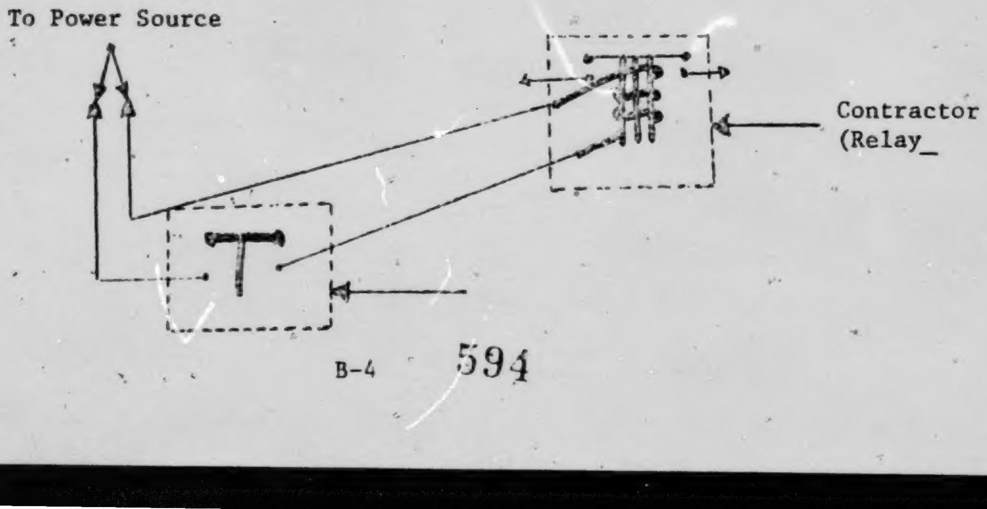

Circuit Breaker
X-Ray Tube
PRV
Prereading Voltmeter
mA
To Power Source
Contractor (Relay)
1:1000 Step-up Transformer

3. Timer - Circuit

a. **Function**

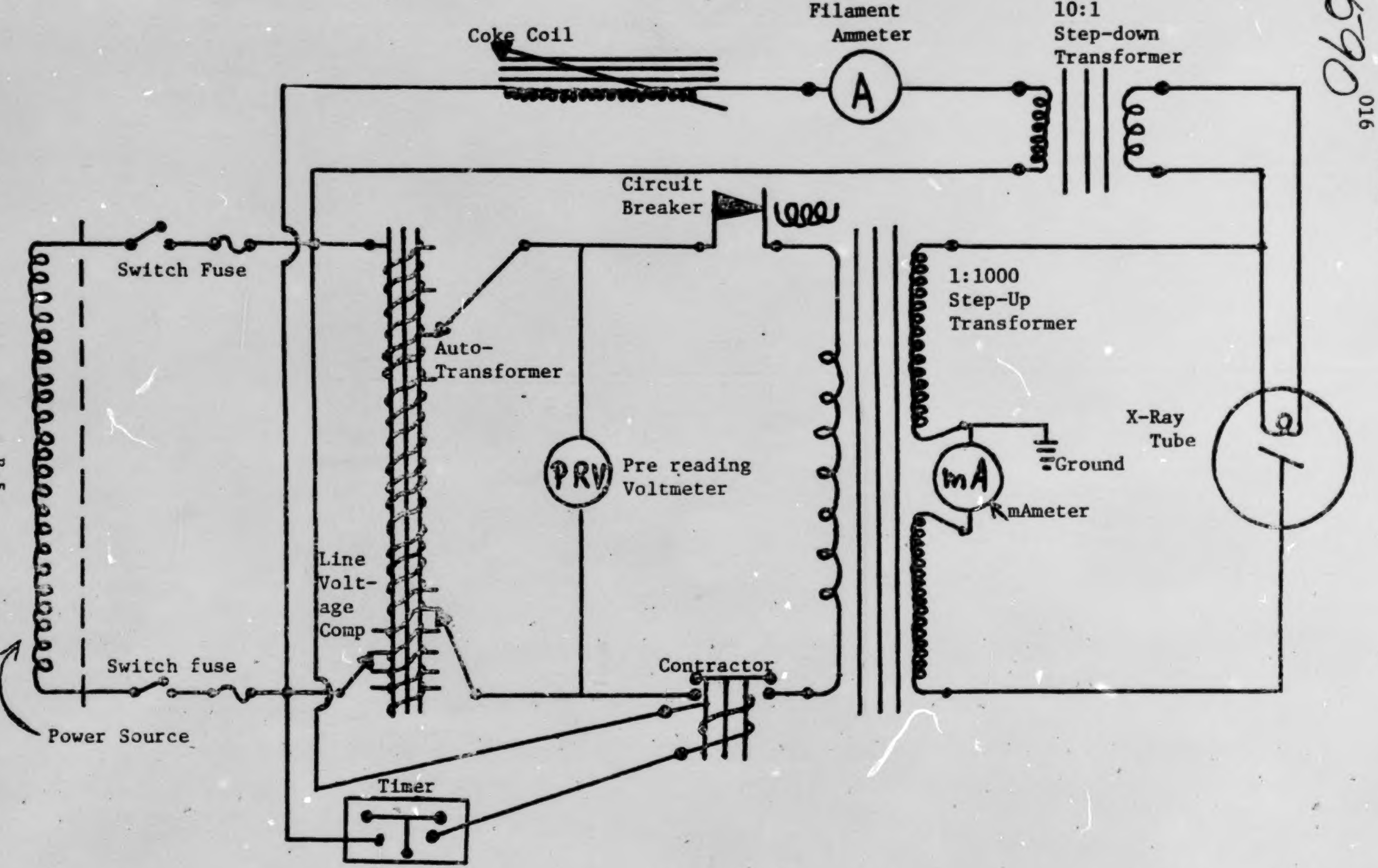
To regulate time of exposure.

b. **Draw Diagram and Label**

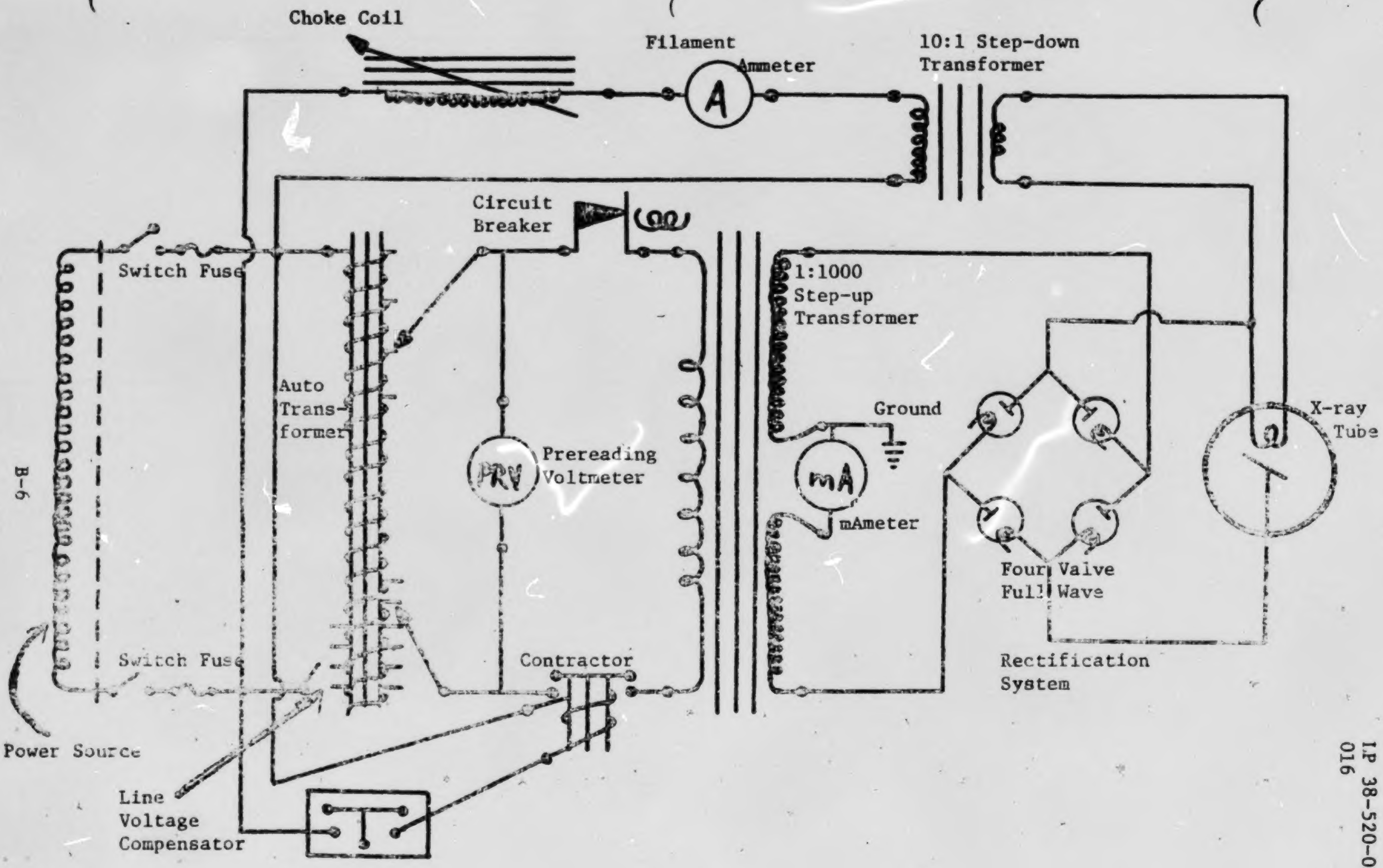

To Power Source
T
Contractor (Relay_

LP 38-520-023
016

B-5


Coke Coil
Filament Ammeter
A
10:1 Step-down Transformer
Circuit Breaker
Switch Fuse
1:1000 Step-Up Transformer
Auto-Transformer
X-Ray Tube
PRV
Pre reading Voltmeter
mA
Ground
mAmeter
Line Voltage Comp
Switch fuse
Contractor
Power Source
Timer

SELF - RECTIFIED : HALF - WAVE X-RAY MACHINE


Choke Coil
Filament Ammeter
A
10:1 Step-down Transformer
Circuit Breaker
Switch Fuse
1:1000 Step-up Transformer
Auto Trans-former
Ground
X-ray Tube
PRV
Prereading Voltmeter
mA
mAmeter
Four Valve Full Wave
Switch Fuse
Contractor
Rectification System
Power Source
Line Voltage Compensator

FOUR-VALVE - FULL WAVE RECTIFIED X-RAY MACHINE

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

Mr. John Mayes
*IM 38-520-023
016

X-Ray Machine Circuits

We have studied separately the parts which make up the X-ray machine and how each one works. Now we must put the parts together to see how the machine produces and controls the x-rays which are produced. At some time, it will become necessary for the specialist to provide minor maintenance or repair to the x-ray machine; consequently, a knowledge of the basic circuit is necessary.

An understanding of these diagrams will enable you to recognize certain types of failures which may occur in the machine. X-ray Specialists are not authorized to do maintenance on a machine but should have some idea of the general location of any trouble that should occur to guide the maintenance men in their repairs.

The symbols we are going to use are included in your TM 8-280, page 27.

We will look at each structure and the corresponding diagram. The diagram usually is drawn as to represent the actual part, that is; a coil of wire is represented by a looped line; an adjustable device is represented by an arrow which indicates motion.

Note that meters are represented by circles which have a letter or group of letters which indicate the type of meter represented. Refer to TM 8-280, page 27. Note that the prereading voltmeter is connected in parallel in the circuit while the ammeter and milliammeter are connected in series.

The ground connection is important from a standpoint of electrical protection.

Fuses are, of course, safety devices to prevent large surges of current from damaging the sensitive portions of the X-ray machine circuitry.

Note the similarity between the symbols for the valve tube and the X-ray tube. The angled anode on the X-ray tube symbol is the distinguishing feature.

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*This instructor's manuscript supersedes IM 38-520-023, 060

The circuit breakers, like the fuses, are safety devices but are usually used to protect specific portions of the X-ray machine while the fuses protect the whole machine.

Note the transformers and in the next row the autotransformers. The single winding of the autotransformers distinguish them from the transformers. Note in the transformers that the loops indicate whether it is a step-up or step-down transformer. Usually the left side is the primary side, but a quick examination should indicate which side is used for power and which for load if any question arises.

The choke coil is represented as a variable device by the arrow.

The timer contractor is simply a push button switch which activates the timer portion of the X-ray machine circuit.

The contractor is a remote control switch. When the coil is energized, it causes the switch to close.

The source of power is usually a transformer, the secondary coil of which is used to represent the source of power.

X-ray Circuit Chart -- see TM 8-280, pages 70-71.

The first of the three main circuits which are in the X-ray machine is the mA circuit. The mA circuit controls the mA or milliamperage which flows across the X-ray tube. The mA circuit consists of the main line, from which the AC power is obtained; the main line switches which turn on the whole machine; the main line fuses which prevent damage to the tube from heavy currents; the choke coil which adjusts the current in the filament of the tube; the step-down transformer which steps up the current to a value which will heat the filament; the filament ammeter which measures the filament current; and the filament of the X-ray tube.

The mA is determined by the heat of the filament--the hotter the filament the more mA is produced. The choke coil is the device which selects the current which will flow through the filament and thus determines the mA which will be produced.

Note that the mA does not flow in the mA circuit. The mA circuit simply controls the amount of mA that is produced. (The mA actually flows in the kVp circuit).

The kVp circuit consists of the main line, switches, and fuses; the line voltage compensator which makes adjustment for changes of incoming voltage; the autotransformer which, by means of the major and minor selector switches; allows us to select any desired voltage; the prereading voltmeter which gives the kilovoltage that will be produced during the exposure; the circuit breaker which protects the high voltage portion of the kVp circuit from overload; the contractor which is a remote control switch to activate the X-ray tube; step-up transformer which changes the voltage to kilovoltage; the mA meter which measures the mA or current flowing from the cathode to the anode of the X-ray tube; The ground, which is to prevent the short through patients or specialists when an electrical short occurs; and X-ray tube which produces the X-rays.

The autotransformer selects the voltage which is to be used. This is read on the prereading voltmeter. No exposure is made until the contractor is closed. This activates the primary side of the step-up transformer which, in turn, activates the X-ray tube and X-rays are produced.

The timer circuit consists of the main line, switches, and fuses; the timer which activates the contractor; the contractor which activates the step-up transformer and X-ray tube.

Only when the timer is closed, will the contractor close the switch to activate the tube. An automatic device will stop the exposure after a preset time.

The importance of understanding the operation of the X-ray machine cannot be minimized. To understand the control of X-ray production the student must know the basic circuitry of the X-ray machine. An understanding of this circuit will enable him to properly adjust his X-ray machine to compensate for factors which ordinarily are not on the technique chart but which may on occasion arise.

595

ACADEMY OF HEALTH SCIENCES *LP 38-520-027
MEDICINE AND SURGERY DIVISION 018
X-RAY BRANCH

Electrical Protection (1 hour)

COURSES PRESENTED TO: 313-91P10, X-Ray Specialist

PLACE: Classroom

REFERENCES:

TM 8-280
Selman, Joseph. The Fundamentals of X-Ray and Radium Physics. 5th ed. Springfield, Illinois: Charles C. Thomas, 1972, page 479.

STUDY ASSIGNMENT: Read TM 8-280, pp 4-26 through 4-30, para 4-43 through 4-48

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 and GR 38-520-001-1C

TOOLS, EQUIPMENT, AND MATERIALS: None

PERSONNEL: One instructor, 91P2H/91P3H/91P4H

INSTRUCTIONAL AIDS: Chalk, chalkboard, and eraser

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Lecture (1st hour)

I. INTRODUCTION (2 min)

A. Opening Statement: Whenever you work with equipment which utilizes a voltage up to 100,000 volts or more, you must always be aware of potential electrical hazards. X-ray machines, of course, will be included among the electrical devices which we must always consider as potentially dangerous.

B. Objectives

1. State the reason for grounding X-ray equipment.

2. State at least two acceptable locations for grounding a portable X-ray machine.

3. State the conditions under which electrical arcing is a hazard when using X-ray equipment.

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*This lesson plan supersedes LP 38-520-027, 087

II. EXPLANATION (40 min)

A. Electrical Grounds

1. Grounding points of machine
2. Reason for grounding: Equipment is grounded in order to protect the X-ray specialist and patient from electrical shock.
3. Grounds in permanently installed machines
4. Grounds in portable machines; water pipes; radiators; grounded electrical conduits
    a. Hospital ward
    b. Field radiography - an iron stake driven several feet into the ground

B. Electrical Sparks (or Arcing) Conditions

1. Oxygen tanks or tents (in many instances, must be administered to patients)
    a. Supports combustion
    b. To avoid explosions
2. Operating room

QUESTION: What is the main danger when using a portable machine in surgery?

ANSWER: There is a great danger of explosion if explosive anesthetics are used. All portable machines used in surgery must be equipped with a grounding device. Also, any illuminators used in surgery must be grounded and should not be located less than five feet above the floor.

C. Darkroom Hazards

1. Faulty insulation in switches
2. Chemicals and water spilled on darkroom floor
3. Improper grounding of processing tanks

D. Effects of Electrocution

1. Fibrillation
2. Blood pressure increases
3. Diaphragm paralyzes
4. Flesh burns

QUESTION: What steps should be followed if you find a fellow specialist suffering from the effects of electrocution?

ANSWER: Do not grasp the victim directly. Use something which does not conduct electricity to move the victim away from the source of current. If the main switch is nearby, this should be turned off. Seek medical aid. Meanwhile, you should apply external cardiac massage, alternating this with mouth-to-mouth resuscitation. Later in the course, you will have a class on the techniques of cardiopulmonary resuscitation (CPR).

E. Effects of Current

1. Threshold of perception - .001 ampere
2. "Can't-let-go-current" - .016 amperes
3. Pain, possible fainting, exhaustion, mechanical injury - .050 amperes
4. Ventricular fibrillation - .100 - 3.0 amperes

F. Questions from Students

NOTE: Read TM 8-280, pp 4-26 through 4-30, para 4-43 through 4-48

III. SUMMARY (3 min)

A. Review of Main Points

1. Never work with wet hands or while standing on a wet floor
2. Anesthetics and oxygen - beware of sparks
3. Be able to give aid to a victim of electrocution

B. Closing Statement: Although the likelihood of electrocution is small in the X-ray clinic, the specialist should always be aware of the possibilities.

ACADEMY OF HEALTH SCIENCES *IM 38-520-027
MEDICINE AND SURGERY DIVISION 018
X-RAY BRANCH

Electrical Protection

Whenever you work with equipment which utilizes a voltage up to 100,000 volts or more, you must always be aware of potential electrical hazards. X-ray machines, of course, will be included among the devices which we must always consider as potentially dangerous electrically. The X-ray specialist must be familiar with the hazards of using high voltage so he can protect both himself and his patient.

ELECTRICAL GROUNDS

When plugging in a portable X-ray machine, always connect the alligator clip to the electrical outlet. This offers an electrical ground. If you will think back to the insert diagram of the X-ray machine, you will recall that there was an electrical ground next to the MA meter in the center of the step-up transformer. All X-ray machines should be grounded when being used. Since all electricity wants to go to ground, if a short occurs in the circuit, the electricity will go to ground and probably burn out a fuse rather than go through you or your patient. Equipment is grounded in order to protect the X-ray specialist and patient from electrical shock.

The electrical ground of permanently installed machines is permanent, and once it is connected, no more note need be taken of it; but in portable machines, the ground must be made before the machine is used.

When using a portable machine in the hospital ward, the machine should be grounded to a pipe, radiator, or electrical conduit which is grounded. It may be necessary to scrape a little paint from the pipes to ensure a good electrical connection.

In field radiography, grounding is accomplished by connecting to an iron stake which is hammered several feet into the ground. If the field generator is grounded, a connection for the X-ray machine may be made to the same ground connection as the field generator.

ELECTRICAL SPARKS

When using a portable machine in the presence of oxygen, care must be taken to avoid sparks caused by closing or opening switches. Although oxygen is not combustible itself, anything that is combustible which is mixed with oxygen will become explosive. In radiographing a patient under oxygen, the machine should be set up and turned on outside the room. When ready to make an exposure, the oxygen should be turned off by a nurse, the tent removed, and a moment allowed to elapse while the oxygen dissipates. An exposure may be made after which the nurse should immediately replace the tent and turn on the oxygen.

Similarly, in an operating room using explosive anesthetics, care must be taken to prevent sparking. Similar treatment with portable machines, if

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*This instructor's manuscript supersedes IM 38-520-026, 034.

used with oxygen, should prevent sparking which could cause violent explosions.

DARKROOM HAZARDS

One of the most common areas for electrical accidents to occur is in the darkroom. This usually occurs at the wash tank and the viewbox. A careless tendency to turn on the viewbox switch while handling film in the water has caused many electrocutions due to a faulty switch.

EFFECTS OF ELECTROCUTION

Electrocution causes several effects. Electricity upsets the normal rhythm of the heart, causing a quivering effect called fibrillation. By external heart massage, the heart can sometimes be restored to normal rhythm. This is done by applying heavy pressure over the sternum with the heel of the hand approximately 60 times a minute. This often returns the heart to a normal beat. Later in the course you will have a class on cardiopulmonary resuscitation.

Blood pressure may also increase to such a point that the tiny capillaries of the brain burst and hemorrage occurs. This, you cannot detect or do anything about with first aid.

Just as the heart may be stopped, so can the diaphragm be paralyzed, causing a suspension of respiration. Mouth-to-mouth resuscitation is the best method of reviving a patient with respiratory arrest.

Flesh is also burned at the point of entry and exit of the current. These burns may be treated as ordinary burns and should only be tended after respiration and heart stoppage have been returned to normal.

These first-aid steps should be taken immediately and then a doctor should be notified.

Various quantities of current have different physiological effects on the body. The threshold of perception, or sensation of tingling, occurs at approximately 0.001 amperes. The "can't-let-go-current" is approximately .016 amperes. Pain, possible fainting, exhaustion, mechanical injury occur at approximately 0.050 amperes. Heart and respiratory function continue. Ventricular fibrillation can occur in the range of .100 - 3.0 amperes.

Although the likelihood of electrocution is small in the X-ray clinic, you should always be aware of the potential hazards.

DEPARTMENT OF THE ARMY
ACADEMY OF HEALTH SCIENCES, U.S. ARMY
FORT SAM HOUSTON, TEXAS 78234

*GR 38-520-001-1
105

# RADIOGRAPHIC PHYSICS
for
Radiographic Procedures (Basic) Course
PART I

*This general reference supersedes GR 38-520-001-1,084,pages 1-32,208-21

TABLE OF CONTENTS
PARTS I, II, III, IV

1st Week -PART I — Page

Weekly Objectives 2
History of X-Rays 3
Theory and Properties of X-Rays 6
Atomic Structure 17
Introduction to Electricity 30
Glossary of Physics Terms 36

WEEK 1

2nd Week-PART II

Weekly Objectives 1
X-Ray Tubes and Rating Charts 2
Exposure Arithmetic 12
Inverse Square Law 39
Primary Factors of Exposure 48
Accessory Devices 56
Radiation Protection 70

WEEK 2

4th Week -PART III

Weekly Objectives 1
Secondary Factors of Exposure 2
Compensation Factors. 15
Radiographic Exposure Technie 31

WEEK 4

5th Week -PART III(included with 4th week)

Weekly Objectives 40
Construction and Handling of X-Ray Film 41
Film Holders and Hangers. 50
Darkroom Construction 57
Darkroom Processing 63
Artifacts 71

WEEK 5

8th Week-PART IV

Weekly Objectives 1
Electricity, Ohm's Law AC and DC 2
Magnetism and Electromagnetism 8
Transformers and Autotransformers 17
Meters. 22
Timers. 27
Rectification 29
X-Ray Machine Circuits 33
Electrical Protection 39

WEEK 8

SCOPE OF RADIOGRAPHIC PHYSICS

Only when electrical and magnetic phenomena are properly utilized and controlled can x-rays be produced; this necessitates an understanding of the basic principles of electricity and magnetism. The concepts of atomic structure, energy, electricity and magnetism are essential for understanding their application in the x-ray machine. The general principles of such electrical devices as the transformer, autotransformer, choke coil, rectification systems, measuring instruments and the x-ray tube and how these devices are constructed and utilized within the x-ray machine will enable the x-ray specialist to understand production and control of radiation so that good quality diagnostic radiographs result.

In most clinics, techniques are standardized. Occasions will arise which require a deviation from the standard technique. An understanding of the effects on the film due to changes in kilovoltage (kV, kVp), milliamperage (mA), milliampere-seconds (mAs), focal-film distance (FFD) and how to select the correct combination of these factors will assist the specialist in making necessary changes from routine clinical techniques.

The principles of x-ray physics, x-ray machine construction and operation, applied physics and mathematics of radiography, darkroom principles and techniques, and electrical and radiation protection are all vital to the understanding necessary to perform the important task of producing diagnostic quality radiographs.

603

WEEKLY OBJECTIVES AND GOALS
FIRST WEEK - PHYSICS

By the end of the first week you will be tested on the following objectives. The examination will consist entirely of multiple choice items.

I. Radiation: (About 45% of the exam)

   A. Describe the discovery of x-rays OR the discovery that x-rays were damaging to human tissues.
   B. Define or describe the relationships which exist between the following terms: cycle, frequency, wavelength, penetration, energy, kind of x-rays.
   C. Identify the properties of x-rays.
   D. Describe x-ray production.

II. Atomic Structure: (About 10% of the exam)

   A. Define: atom, element, molecule, ion, atomic number, atomic weight, isotope.
   B. Describe the Bohr theory and its application to primary radiation production.

III. Electricity: (About 15% of the exam)

   A. Define: voltage, current, resistance, law of electrostatics.
   B. Describe the units of voltage, current, and resistance (and the factors which affect resistance).

IV. Math: (About 30% of the exam)

   A. Compare any of the following sets of measurements:

      1. inches--centimeters
      2. meters-centimeters--millimeters
      3. Angstroms--meters--centimeters
      4. the prefixes kilo- and milli-

   B. Given pertinent factors and the formulas to be used calculate the unknow of any of the following forms:
      1. $A \times B = C$
      2. $A \times B = C \times D$
      3. $\frac{A}{B} = \frac{C}{D}$
      4. $A = B \times \frac{(X^2)}{Y^2}$

   C. Using the formula from memory convert a given value of inches to centimeters or centimeters to inches.

HISTORY OF X-RAY

OBJECTIVES:

State:
1. who discovered x-rays, how, when (year).
2. the contributions of Dr. Grubbe to radiology.
3. the two medical areas which utilize x-rays.

A. Pre-X-ray History

B. Discovery of X-ray

1. Observation

2. Publication

605

3. Awards

C. Post-X-ray History

1. Medical uses

2. Industrial uses

3. Research

612

HISTORY OF RADIOGRAPHY

Discoveries relating to electricity preceded the discovery of x-ray in 1895 by Wilhelm Conrad Roentgen, a German physicist. Roentgen was experimenting with cathode rays, using a Crookes-Hittorf vacuum tube, inclosed in black paper, through which a high voltage current was being passed. He observed a fluorescence of some barium platinocyanide crystals coated on a piece of cardboard nearby and realized this was due to some unknown type of ray that could pass relatively unhampered through the black paper. When he picked up the chemical-coated cardboard, his fingers came between it and the tube and he saw the bones in his hand. He noted the presence of a ray that would penetrate solid matter, that could not be reflected or refracted by the usual means, that was not affected by electrical and magnetic fields. By replacing the chemical coated cardboard with a photographic plate, he recorded an image of the internal structures of his wife's hand.

Today, x-rays are utilized by the medical profession in diagnosis, in studying bone fractures, in locating foreign substances in the body, and in therapeutically treating cancer and benign conditions.

THEORY AND PROPERTIES OF X-RAYS

OBJECTIVES:

1. Convert centimeters to inches and vice versa.

2. Identify the following on a diagram of a sine wave:
   a. one cycle.
   b. wavelength.
3. Define: Frequency, Cycle, Wavelength.
4. Match all others when given a comparative value of any one of the following: frequency, wavelength, energy, penetration, kind of ray.
5. List at least seven properties of x-rays.

A. Metric System

C. Centimeters Formula

1. Theory

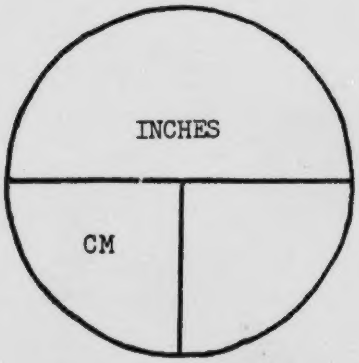
2. Formulas

a. Inches = Centimeters X ____________________

b. Centimeters = ______Inches______

____

c. Memory Wheel



609

4. Problems

a. 15 cm = ______________ in

* b. 21 cm = ______________ in

c. 12 cm = ______________ in

d. 4 in = ______________ cm

* e. 2½ in = ______________ cm

f. 9 in = ______________ cm

g. 9 cm = ______________ in

h. 10 in = ______________ cm

i. 7 cm = ______________ in

j. 8 in = ______________ cm

616

B. Electromagnetic Concept

C. Electromagnetic Wave--Sine Wave

1. Sketch illustration

2. Terms

A. Cycle

(1) Definition:

(2) Sketch illustration

b. Frequency

(1) Definition:

(2) Sketch illustration

c. Wavelength

(1) Definition:

(2) Sketch illustration

D. Electromagnetic Rays

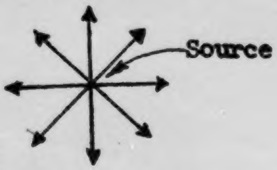
1. Similarities

2. Differences

E. Properties of X-rays (List)

ELECTROMAGNETIC RADIATION

When energy is emitted from a small source and moves outward in all directions, we say the source is radiating energy.



There are two types of radiating energy-- corpuscular (particle) and electromagnetic.

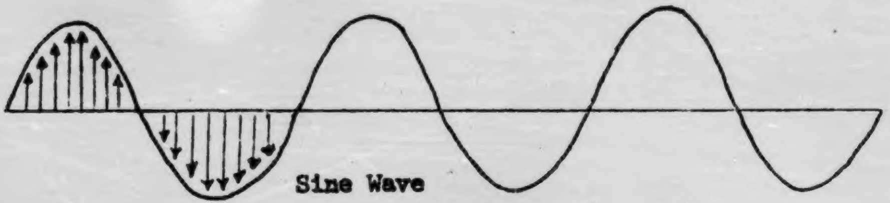
Corpuscular radiation is in the form of high speed particles of matter and may have a positive, negative, or neutral electrical charge. Corpuscular rays are often emitted from the nucleus of radioactive atoms.

Electromagnetic radiation is not considered to be any particle. We say simply, that an electromagnetic ray is a "bundle" or "packet" of energy which we call a PHOTON or QUANTUM. Radio waves, light rays, and x-rays are examples of electromagnetic rays. ALL electromagnetic rays travel at the speed of light (186,000 miles per second).

X-rays are similar, in many respects, to infrared or heat waves, visible light, ultraviolet light, gamma rays, and other forms of electromagnetic energy. The theory that they are all electromagnetic waves was established by Maxwell, a British physicist, who showed that when electrical charges vibrate they also produce waves which spread out from the center of the vibration.

The photon or quantum of electromagnetic energy carries with it both electric and magnetic fields. Both of these fields are rapidly changing in strength and direction of action.

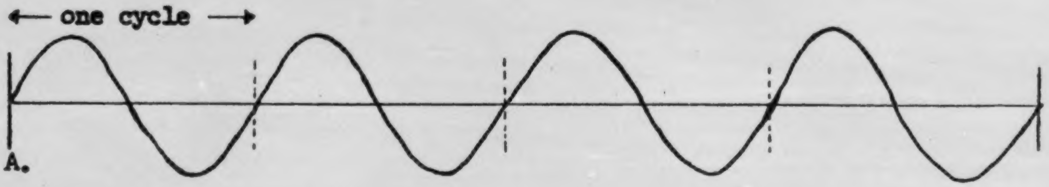
The changing electric and magnetic fields can be represented by a mathematical curve called a sine wave.

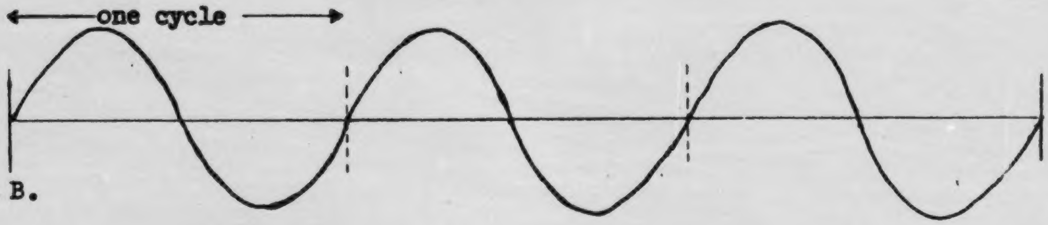


The straight line represents zero strength of the electric or magnetic field and moving from left to right represents the passage of time. The curve above the line represents the electric or magnetic strength acting in one direction and the curve below the line represents the field acting in the other direction. The distance above or below the line indicates the relative strength of the field at any given moment.

Note the repetition of the sine wave. The section which is indicated by the varying length of arrows forms one CYCLE of the repeating curve. Note that a continuation of the curve beyond one cycle will be a repetition of some part of the original cycle.

Here are diagramed two different electromagnetic rays.



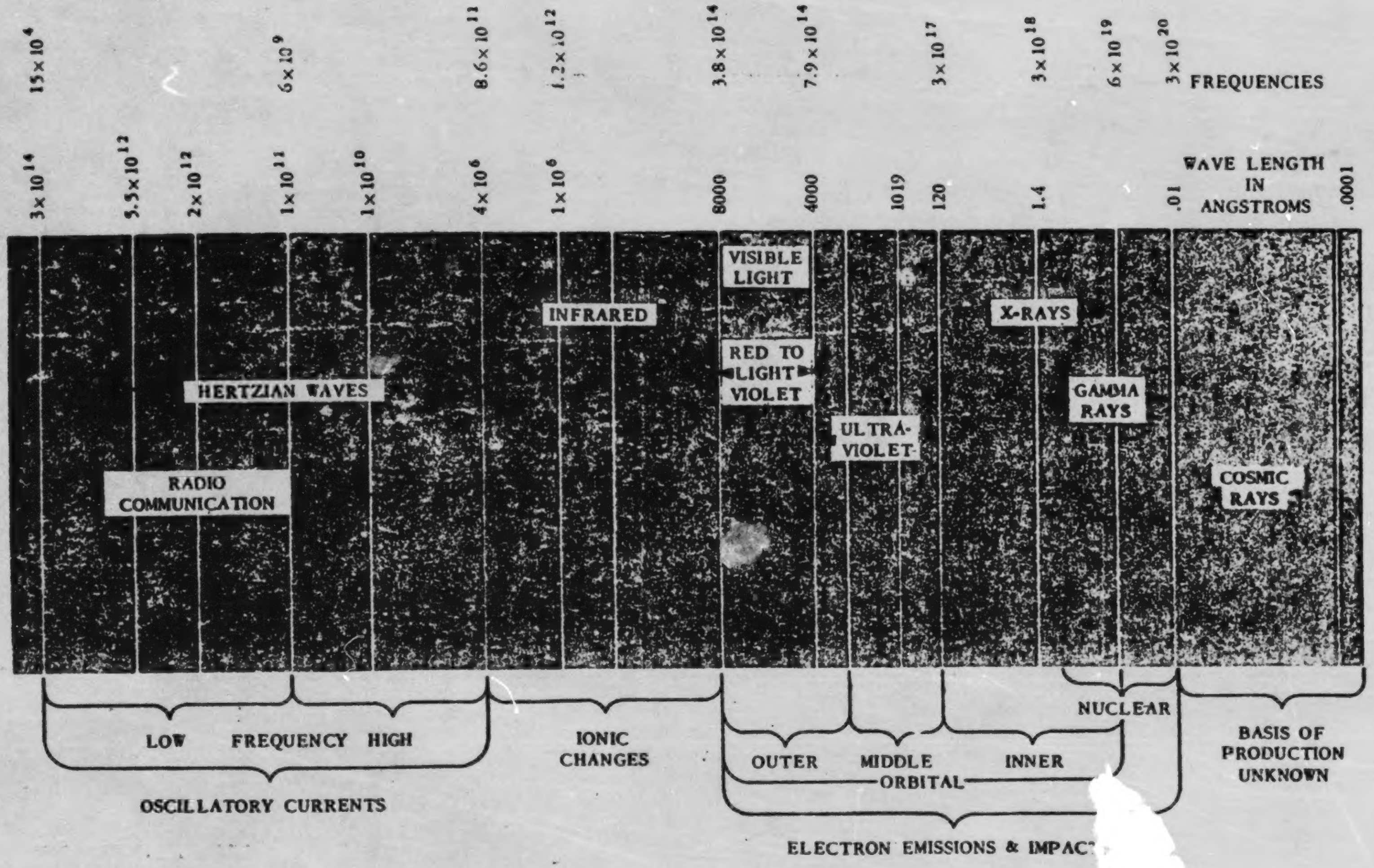


Ray B has a longer cycle than ray A. The linear distance traveled by one cycle is its WAVELENGTH. Ray A has a shorter wavelength than ray B.

In x-ray the shorter the wavelength the more energy the x-ray possesses and the deeper it will penetrate.

X-rays A and B travel the same speed (186,000 miles per second) If they start together and go the same direction, they will reach the end point at the same time. Note, however, that ray A goes through about four cycles in the same time that ray B goes through only three cycles. Since it takes the same time to travel the same distance cycles occur in ray A more often than in ray B. The number of cycles per second is termed frequency. We say that ray A has a higher frequency than ray B.

Note that rays having a longer wavelength also have a lower frequency and vise versa.


FREQUENCIES
15×10^4
6×10^9
8.6×10^11
1.2×10^12
3.8×10^14
7.9×10^14
3×10^17
3×10^18
6×10^19
3×10^20
WAVE LENGTH IN ANGSTROMS
3×10^14
5.5×10^12
2×10^12
1×10^11
1×10^10
4×10^6
1×10^6
8000
4000
1019
120
1.4
.01
.0001
VISIBLE LIGHT
INFRARED
X-RAYS
RED TO LIGHT VIOLET
HERTZIAN WAVES
GAMMA RAYS
ULTRA-VIOLET
RADIO COMMUNICATION
COSMIC RAYS
LOW FREQUENCY HIGH
OSCILLATORY CURRENTS
IONIC CHANGES
NUCLEAR
OUTER
MIDDLE
INNER
ORBITAL
ELECTRON EMISSIONS & IMPACT
BASIS OF PRODUCTION UNKNOWN

Electromagnetic spectrum.

All electromagnetic rays travel at the speed of light. There are, however, many different kinds of rays. When these rays are arranged in order of energy or wavelength, they form what is called the ELECTROMAGNETIC SPECTRUM.

Starting with the lowest energy (longest wavelength) rays that are useful to man, we have, in order:

> radio waves--TV waves--radar waves--infrared waves--visible light (visible light has its own spectrum in order of red, orange, yellow, green, blue, violet)--ultraviolet light--x-ray--gamma rays.

Note the position of x-ray with respect to the other types of radiation. The x-ray which we will use in diagnostic x-ray work will be of higher energy (shorter wavelength) than ultraviolet light but of lower energy (longer wavelength) than gamma rays.

Questions and Problems

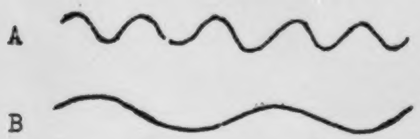
Match the following items (items may be used more than once):

____1. A complete portion of a sine wave. (Any further portion duplicates it.)
____2. The shorter the wavelength the higher the frequency and the greater the __?__.
____3. Any single electromagnetic ray.
____4. Speed of radio, light, x-ray, etc.
____5. Number of cycles per second.
____6. Linear distance covered by one cycle.

a. frequency
b. frequency per sec
c. speed
d. wavelength
e. cycle
f. proton
g. penetrating power
h. photon
i. 186,000 mile/s
j. 186,000 mile/hour

Which x-ray (A or B):

____7. has the higher frequency?
____8. has the least energy?
____9. has the longest wavelength?
____10. will penetrate deepest?



11. A patient who measured 18 cm. would be about ____inches.

12. A patient measuring 10 inches in the chest would be about ____cm.

13. Why is it important for you as future x-ray technicians to know the properties and characteristics of x-ray?

ATOMIC STRUCTURE

OBJECTIVES:

1. Identify definitions or descriptions of the following terms: atom, element, proton, electron, neutron, atomic number, atomic weight, isotope, ion, energy level; primary and secondary radiation production.

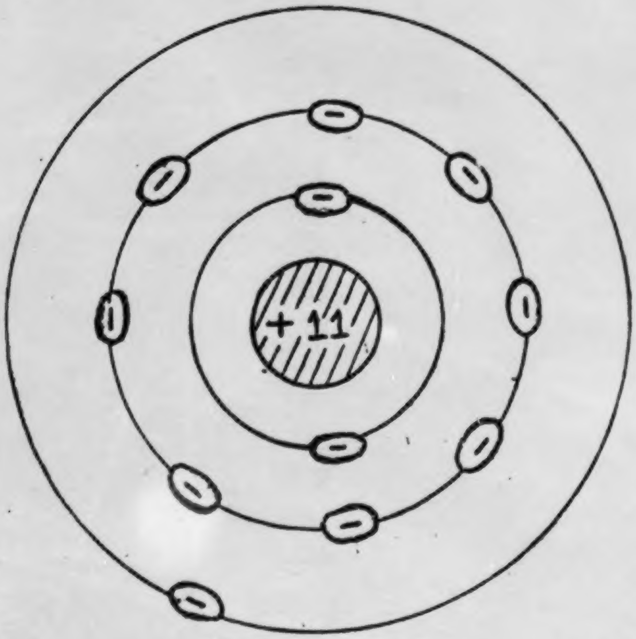
2. Describe: the two methods of primary x-ray production and relative amounts of each in the x-ray beam; the process of ionization; the Bohr theory of atomic structure.

A. Energy

619

B. Atomic Theory

1. BOHR Theory



Atomic model as envisioned by the Bohr theory. This diagram represents an atom of sodium with 11 electrons revolving in orbit about the positive nucleus.

2. Subatomic Particles
   - a. Proton
   - b. Neutron
   - c. Electron

3. Orbital Shells

4. Atomic Cohesive Forces

PERIODIC TABLE OF THE ELEMENTS

Table of Radioactive Isotopes

[illegible]

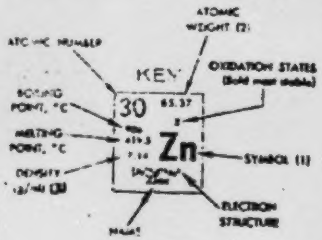
Naturally occurring radioactive isotopes are indicated by a blue mass number. Half lives are in parentheses where s, m, h, d and y stand for seconds, minutes, hours, days and years respectively. The symbols describing the mode of decay and resulting radiation are defined as follows

α	alpha particle	L	L electron capture
β^-	beta particle	SF	spontaneous fission
β^+	positron	γ	gamma ray
K	K electron capture	e^-	internal electron conversion

GROUP IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIII	VIII	VIII	IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
1 H 1.00797 Hydrogen																	2 He 4.0026 Helium
3 Li 6.939 Lithium	4 Be 9.0122 Beryllium											5 B 10.811 Boron	6 C 12.01115 Carbon	7 N 14.0067 Nitrogen	8 O 15.9994 Oxygen	9 F 18.9984 Fluorine	10 Ne 20.183 Neon
11 Na 22.9898 Sodium	12 Mg 24.312 Magnesium											13 Al 26.9815 Aluminum	14 Si 28.086 Silicon	15 P 30.9738 Phosphorus	16 S 32.064 Sulfur	17 Cl 35.453 Chlorine	18 Ar 39.948 Argon
19 K 39.102 Potassium	20 Ca 40.08 Calcium	21 Sc 44.956 Scandium	22 Ti 47.90 Titanium	23 V 50.942 Vanadium	24 Cr 51.996 Chromium	25 Mn 54.938 Manganese	26 Fe 55.847 Iron	27 Co 58.9332 Cobalt	28 Ni 58.71 Nickel	29 Cu 63.54 Copper	30 Zn 65.37 Zinc	31 Ga 69.72 Gallium	32 Ge 72.59 Germanium	33 As 74.922 Arsenic	34 Se 78.96 Selenium	35 Br 79.909 Bromine	36 Kr 83.80 Krypton
37 Rb 85.47 Rubidium	38 Sr 87.62 Strontium	39 Y 88.905 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.906 Niobium	42 Mo 95.94 Molybdenum	43 Tc (98) Technetium	44 Ru 101.07 Ruthenium	45 Rh 102.905 Rhodium	46 Pd 106.4 Palladium	47 Ag 107.870 Silver	48 Cd 112.40 Cadmium	49 In 114.82 Indium	50 Sn 118.69 Tin	51 Sb 121.75 Antimony	52 Te 127.60 Tellurium	53 I 126.9044 Iodine	54 Xe 131.30 Xenon
55 Cs 132.905 Cesium	56 Ba 137.34 Barium	57 La* 138.91 Lanthanum	72 Hf 178.49 Hafnium	73 Ta 180.948 Tantalum	74 W 183.85 Wolfram	75 Re 186.2 Rhenium	76 Os 190.2 Osmium	77 Ir 192.2 Iridium	78 Pt 195.09 Platinum	79 Au 196.967 Gold	80 Hg 200.59 Mercury	81 Tl 204.37 Thallium	82 Pb 207.19 Lead	83 Bi 208.980 Bismuth	84 Po (210) Polonium	85 At (210) Astatine	86 Rn (222) Radon
87 Fr (223) Francium	88 Ra (226) Radium	89 Ac** (227) Actinium	104														

*	58 Ce 140.12 Cerium	59 Pr 140.907 Praseodymium	60 Nd 144.24 Neodymium	61 Pm (147) Promethium	62 Sm 150.35 Samarium	63 Eu 151.96 Europium	64 Gd 157.25 Gadolinium	65 Tb 158.924 Terbium	66 Dy 162.50 Dysprosium	67 Ho 164.930 Holmium	68 Er 167.26 Erbium	69 Tm 168.934 Thulium	70 Yb 173.04 Ytterbium	71 Lu 174.97 Lutetium
**	90 Th 232.038 Thorium	91 Pa (231) Protactinium	92 U 238.03 Uranium	93 Np (237) Neptunium	94 Pu (242) Plutonium	95 Am (243) Americium	96 Cm (247) Curium	97 Bk (247) Berkelium	98 Cf (249) Californium	99 Es (254) Einsteinium	100 Fm (253) Fermium	101 Md (256) Mendelevium	102 No (254) Nobelium	103 Lw (257) Lawrencium

20



NOTES:

(1) Black — solid.
Red — gas.
Blue — liquid.
Outline — synthetically prepared.

(2) Based upon carbon – 12. ( ) indicates most stable or best known isotope.

(3) Values for gaseous elements are for liquids at the boiling point.

621

5. Atomic Definitions

   a. Atomic Number

   b. Atomic Weight

   c. Isotope

6. Ionization Process

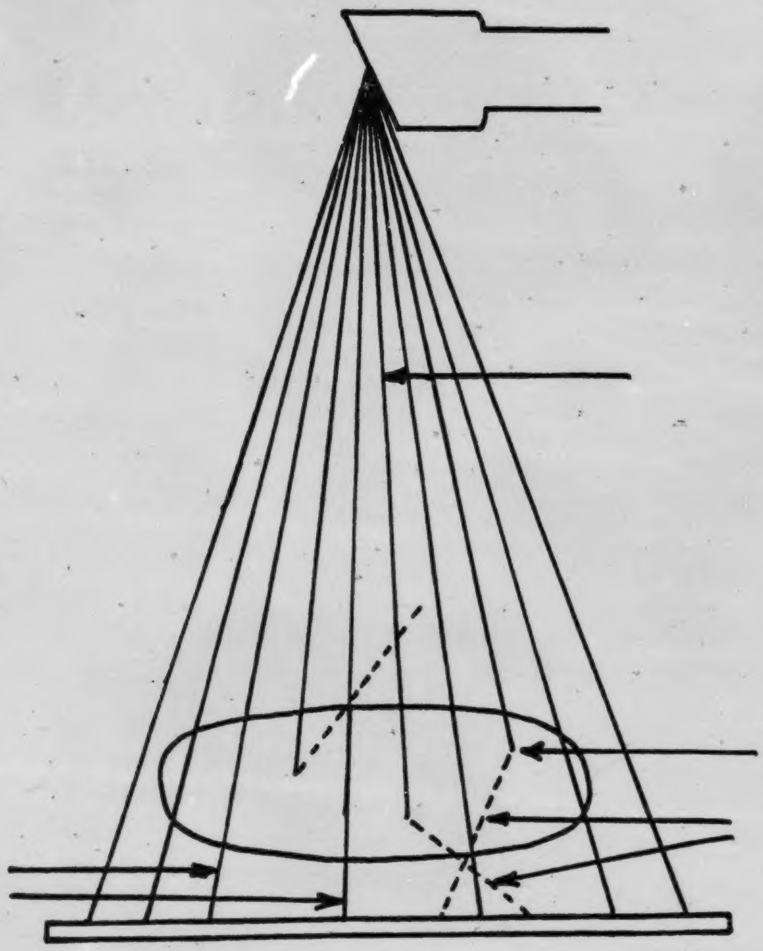
7. X-ray Tube Target Material & Characteristics

E. Methods of X-ray Production

1. Characteristic method

2. Bremsstrahlung (braking) method

F. Types of Radiation

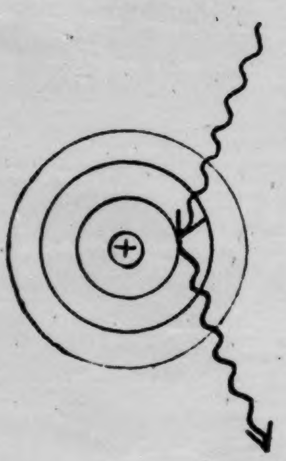


(Scatter)
G. Secondary Radiation Production

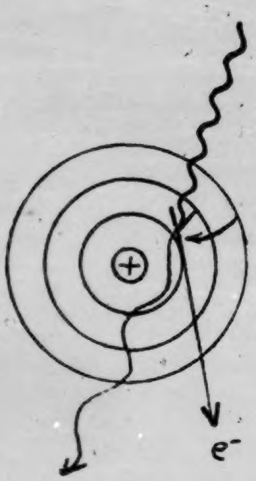
1. Definition

2. Types of Secondary Radiation

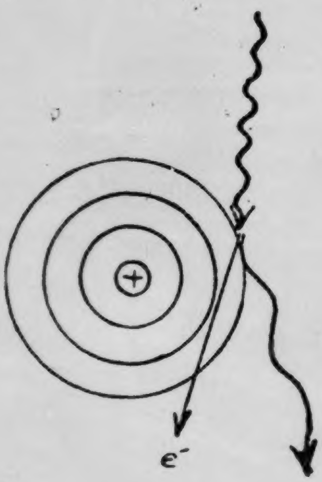
a. Unmodified Scatter



b. Photoelectric Effect



c. Compton Effect



ATOMIC STRUCTURE

One of the general properties possessed by all matter is termed "inertia," the resistance which a body offers to any change in its state of rest or motion. To impart motion to a body at rest, it must be pushed or pulled; to stop a body in motion or to change its direction, some outside force must be applied. Force is the push or pull applied to a body to change its inertia. This outside action or force is attributed to some body other than the one acted upon.

Work, the overcoming of resistance, involves two fundamental physical quantities--force and distance. The work done equals the moving force times distance the object is moved. Doubling the force and keeping the distance the same or doubling the distance while keeping the force the same, will double the work done. Thus, work equals force times distance.

Energy is the capacity for performing work. The amount of work a body can do is limited by the amount of energy it possesses. Hence, work and energy are expressed in the same units. Energy exists in two distinct forms, kinetic and potential.

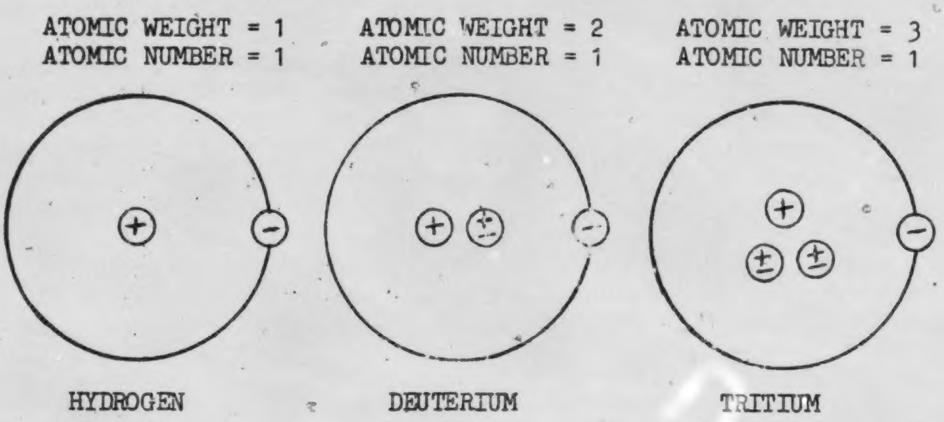
The total of a given amount of energy is never increased or decreased. The Law of Conservation of Energy states that energy cannot be created or destroyed, but can only be transformed from one form to another.

Energy occurs in various forms, many of which are some form of KE. The most common of these are heat, light, sound, electricity, mechanical energy and chemical energy. The electric battery which changes chemical energy to electric energy is an example of the transformation of energy; the steam engine which uses heat to evaporate water and produce steam, which, in turn, is allowed to expand to produce mechanical energy affords another example. These are examples of the Law of Conservation of Energy. There are innumerable others, for energy is constantly changing from one form to another, yet is never destroyed.

Atoms having the same number of protons but different numbers of neutrons in the nuclei are called isotopes. There can be different numbers of neutrons in the nucleus, but if the number of protons are the same we have the same kind of atoms. Hydrogen atoms are hydrogen atoms because they have one proton in the nucleus.

Some isotope combinations of protons and neutrons are stable--that is, they will remain just as they are. Other combinations are unstable and want to change to a more stable form. Isotopes with unstable nuclei are called radioactive isotopes.

Radioactive isotopes are dangerous since they emit radiations of (either or both) high energy corpuscular (alpha rays, beta rays) and electromagnetic (gamma rays) character. Certain radioactive isotopes are used in the radiology department for both treatment and diagnosis of disease along with x-rays. Unauthorized personnel are not permitted to enter areas of radioactivity in a radioisotope portion of the radiology department.



(Isotopes of hydrogen. All have the same atomic number but different atomic weights. (Note: ⊕ is a proton, ⊖ is an electron, and (±) is a neutron.)

The electrons are not arranged haphazardly about the nucleus. They fall very orderly into shells at predictable distances from the nucleus. These shells are called orbital shells. Only a limited number of electrons can exist at a given level (shell).

The first shell (next to the nucleus, called the "K" shell) may have one or two electrons. Under no conditions, however, can it hold more than two electrons. The next shell ("L" shell) can hold as many as (anything from zero) eight electrons, but no more. Here is a list of the shells from the nucleus outward and the maximum number of electrons found in the 92 naturally occurring elements.

K shell (1st)	2 electrons
L shell (2d)	8 electrons
M shell (3d)	18 electrons
N shell (4th)	32 electrons
O shell (5th)	18 electrons
P shell (6th)	12 electrons
Q shell (7th)	2 electrons

The outside shell of an atom can never hold more than 8 electrons. The next larger atom (with one more electron) always makes a new shell for the next electron.

The different shells of the electron cloud represent different levels of electron energy. The electrons in the "K" shell are held more tightly than those in the "L" shell, which are in turn held more tightly than those in the "M" shell, etc. The more tightly the electrons are held, the more energy it requires to remove an electron from that shell.

The outer shells require little energy to remove an electron. Naturally, the atom will not of itself emit an electron from its shell. To do this, energy must be put into the atom from outside.

If an orbital electron is removed from an atom or is added to a neutral atom, the atom does not change its identity because it retains all of its protons. This process of gaining or losing electrons is called ionization. An unstable situation is created because of unequal distribution of positive and negative charges. In either gain or loss of electrons, the atom is electrically unbalanced--the atom acquiring electrons becomes negatively charged because of excessive electrons; the atom losing electrons becomes positively charged because of a lack of electrons. These charged atoms or groups of atoms are ions; a negative ion has extra electrons and a positive ion has some electrons missing.

The production of ions from neutral atoms is ionization. There are several methods by which this can be done:

(1) X-ray bombardment of matter. When x-rays strike matter, they eject electrons from the atoms of the material hit. Such atoms become positive ions. These ejected electrons may combine with the positive ions to form neutral atoms again, or they may combine with neutral atoms to produce negative ions.

(2) Electron bombardment of matter. Fast-moving electrons have a property of ionizing atoms by collision. When fast-moving electrons collide with orbital electrons of other atoms, they dislodge them from their position and remove them completely from these atoms. The atom is then positively charged. Ionization by x-rays or fast-moving electrons is short-lived because ions formed in this way are rapidly neutralized.

The concept of ionization is of great importance in radiology. Ionization in body tissues is of fundamental importance in the production of radiation effects and forms the basis for the therapeutic use of x-rays. Ionization of air by x-rays is one of the most accurate means of measuring the intensity or energy of an x-ray beam.

When an electron is forced out of the atom (away from the nucleus), energy is put into the atom. Conversely, when an electron shifts into a vacancy near the nucleus, energy is given out of the atom. Energy emitted from atoms due to the electron shifting from outer shells to inner shells is in the form of electromagnetic radiation.

If the amount of energy in the electron shift is small, the wavelength of the electromagnetic ray will be long. This may form a radio wave, infrared ray, visible light or ultraviolet light depending upon the energy of the electron shift. [illegible] the energy is high enough, the radiation will be of sufficiently short wavelength to be x-rays.

X-rays are usually made by electrons shifting from any outer shell into the "K" or "L" shell of an atom. The energy and wavelength of these x-rays is determined by the number of shells the electron passes and by which shell (K or L) has the vacancy. "K" shell x-rays are more penetrating than "L" shell x-rays.

X-rays emitted from the x-ray tube are known as primary radiation. X-rays are formed whenever high speed electrons bombard a hard, dense, target. In their formation, two fundamental processes are involved:

(1) The first of these two processes is called "Characteristic Radiation Production." It occurs when an electron with enough kinetic energy collides with one of the inner orbit electrons of a target atom, forcibly ejecting it from its atom. These ejected electrons become photoelectrons. For the production of this photoelectron, energy had to be applied to the atom leaving it in an unstable or excited state. This state is transient, for almost immediately an electron from one of the outer orbits of the atom moves in to fill the place vacated. A definite amount of energy was imparted to the atom to eject the electron, and the same amount of energy must be emitted when the ejected electron is replaced. This energy emerges in the form of x-rays known as characteristic of the target material. The higher the atomic number of the target material, the shorter are the wavelengths of the characteristic rays.

(2) The second process of radiation production is referred to as "Bremsstrahlung"(braking) radiation. Many of the electrons, because of their negative charge, are slowed down (decelerated) as they pass near the positively-charged nuclei of the target atoms. As a result of deceleration, there is a loss of kinetic energy which is converted to an x-ray of equal magnitude. These rays are of many different wavelengths.

The target, which is the source of x-rays, must withstand heavy bombardment and very high temperatures. In the choice of target material, two important factors must be considered. First, the material must have a very high melting point to withstand the intense heat generated within the tube. Secondly, it must have a high atomic number if it is to produce efficiently the quantity of short wavelength radiation useful in roentgenology. Tungsten, having a melting point of 3370° C. and atomic number 74, satisfies both requirements.

Questions and Problems

Match the following items (items may be used more than once if appropriate):

_____ 1. Located in orbital shells
_____ 2. Any electromagnetic ray
_____ 3. Located in nucleus
_____ 4. Has negative charge
_____ 5. Has no charge
_____ 6. Has positive charge

a. Proton
b. Neutron
c. Electron
d. Photon

7. How many electrons would a neutral nitrogen atom have? (Nitrogen atom has seven protons and seven neutrons in the nucleus.)

8. X-rays are produced when electrons shift from the outer shells to the___or___shells.

9. Which electron shift will produce x-rays of shorter wavelength? An electron shift from:

A. N shell to the K shell.
B. N shell to the L shell.

10. Which electron shift will produce x-rays of deeper penetration?

A. N shell to K shell.
B. O shell to K shell.

Match the following items (use items only once):

_____ 11. Method of production of primary radiation in which distinct wavelengths are produced.
_____ 12. Secondary radiation in which photon is annihilated.
_____ 13. "Braking" radiation.
_____ 14. Photon enters atom, loses energy and changes direction.
_____ 15. Photon interacts with an atom and leaves the atom with the same energy but in a different direction.

a. Unmodified scatter
b. Photoelectric
c. Characteristic
d. Compton
e. Bremsstrahlung

631

INTRODUCTION TO ELECTRICITY

OBJECTIVES:

1. Identify or State:
    a. the four factors which affect the electrical resistance of a conductor.
    b. the type of current (AC, uniform DC, pulsating DC) represented when a given diagram of that current or a description of how it flows is given.
2. Define the terms: Voltage, Current, Resistance.
3. Match the terms Voltage, Current and Resistance with their respective units.
4. Convert:
    a. volts to kilovolts.
    b. kilovolts to volts.
    c. amperes to milliamperes.
    d. milliamperes to amperes.

A. Electricity

B. Fundamental Law of Electrostatics

C. Types of Electricity

1. ______________________

    a. Definition

    b. Example

640

632

2. ____________________

a. Definition

b. Types

(1) ____________________

(a) Definition

(b) Types

(2) ____________________

(a) Definition

D. Three Basic Electrical Factors

1. ____________________

a. Definition

b. Synonyms

c. Unit of measure

d. Measuring instrument

e. Sources

2. ____________________

a. Definition

b. Unit of measure

c. Measuring instrument

634

3. ______________________

a. Definition

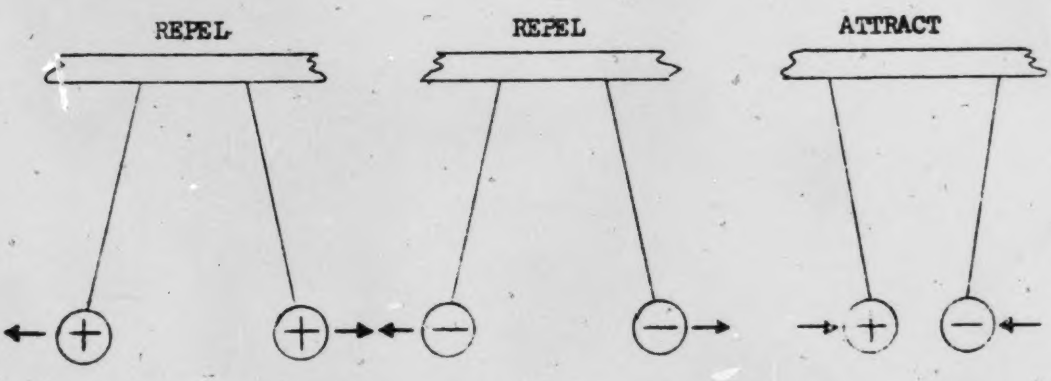
b. Unit of measure

c. Factors controlling resistance

ELECTRICITY

Like charges repel each other; unlike charges attract each other. This is the fundamental law of electricity. This attraction or repulsion is mutual and is easily demonstrated. If two bodies are negatively (or positively) charged they repel each other and remain separated. If one is negatively charged and the other is positively charged, they attract each other. The force of attraction (or repulsion) between two charged particles is directly proportional to the product of their charges and inversely proportional to the square of the distance between them.

Since the positively charged ion is so much heavier and larger than the freed electron, positive charges are less mobile than the lighter negatively charged electrons. Usually only negative charges (electrons) move in a solid conductor; consequently, only negative charges move through a wire. The electrons in the outer orbits, called free electrons, are not tightly bound to the atom; these are the ones which may move freely from atom to atom.



Like charges repel; unlike charges attract

Voltage is produced by the separation of negative and positive charges. We define voltage as a push or pull on electrons but voltage itself does not move. In many ways voltage is analogous to gravity. Gravity is the push or pull that makes objects move (fall) but gravity itself does not move.

When we want to use very large voltages, other than the standard unit of voltage which is the volt, it is often convenient to use the unit KILOVOLT (kV). The kilovolt is a unit of measurement of voltage 1,000 times as large as one volt. (Usually written kVp; the p stands for peak).

1,000 volts = 1 kVp
10,000 volts = 10 kVp
100,000 volts = 100 kVp

Current is measured in the unit AMPERE. The ampere is a measure of the rate of electron flow (i.e., the number of electrons flowing per second). One ampere represents a certain number of electrons flowing per second; the number is about 6,300,000,000,000,000,000 electrons.

When we want to measure very small electric currents a smaller unit, the MILLIAMPERE, is often used. One milliampere (mA) is 1/1,000 of an ampere.

$$1 \text{ mA} = \frac{1}{1,000} \text{ ampere}$$

$$\frac{5}{1,000} \text{ ampere} = 5 \text{ mA}$$

Questions and Problems

Match the following items (items on right may be used only once.)

____ 1. Push that makes electrons move.
____ 2. Unit of measurement of large voltage.
____ 3. Unit of measurement of very small current.
____ 4. Movement of electrons from one point to another. (general term)
____ 5. Holds back flow of electrons.
____ 6. Normal unit of measurement of electrical push.
____ 7. Normal unit of measurement of electric current.
____ 8. Unit of measurement of electric resistance.

a. Resistance
b. Ampere
c. Kilovolt
d. Ohm
e. Voltage
f. mA
g. Volt
h. Millivolt
i. Kiloampere
j. Current

Glossary of Physics Terms

ABRASION MARKS: Artifacts appearing on the film after development due to scratching or rough handling.

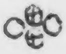
ABSORPTION: Transformation of radiant energy into other forms of energy when passing through a material substance.

ACTUAL FOCAL SPOT: The area bombarded by the electrons in an x-ray tube.

ADDED FILTER: A filter designed to be placed in the portal of the tube housing for additional filtration. Usually made of aluminum to remove the soft wavelength rays.

AIR BELLS: An artifact appearing on a finished radiograph due to improper circulation of the developer solutions.

ALPHA PARTICLES: Charged particles emitted from the nuclei of some atoms and having a mass of 4 units and 2 unit positive electrical charges. They are composed of 2 neutrons and 2 protons. Symbols are:



$_2He^4$

ALPHA RAY: Stream of fast-moving alpha particles; a strongly ionizing and weakly penetrating radiation.

ALTERNATING CURRENT: A flow of electrons which continuously changes speed and also direction of flow in a wire.

ALTERNATION: One-half a cycle of alternating current.

AMPERE: The unit of measurement of current indicating the quantity of electrons which flows through a conductor in one second.

ANODE: Generally, the portion of the tube containing the target and target stem; also refers to the positive or plate side of the tube.

ANODE HEEL EFFECT: The variation in intensity of output of x-rays from the cathode to the anode sides of the tube on the long axis.

ANODE THERMAL CAPACITY: The quanitative ability of the anode portion of an x-ray tube to store, withstand, and dissipate large amounts of heat.

ARTIFACT: Any abnormal mark appearing on a finished radiograph usually caused by mishandling of film or poor processing technique.

ARTIFICIAL MAGNET: A magnet that is made by man by artificial means, such as stroking or induction.

ATOM: The smallest particle of matter retaining all of the chemical properties of the element to which it belongs, and made up of protons, electrons, and neutrons.

ATOMIC MASS UNIT (AMU): The unit of measure used in determining the weight of an atom. $1 \text{ AMU} = 1.67 \times 10^{-14}$ gram.

ATOMIC NUMBER: The number of positive charges (protons) in the atomic nucleus.

ATOMIC RADIATION: Radiation produced by energy changes in atomic nuclei or atomic electron clouds: ionizing radiation.

ATOMIC WEIGHT: The weight of atoms as compared to the arbitrarily assigned weight of oxygen as 16. It is approximately equal to the sum of all protons and neutrons within the nucleus.

AUTOTRANSFORMER: A device used in the x-ray machine for selecting the voltage.

BACKGROUND: The counting rate or the ionizing radiation produced by cosmic radiation and naturally occurring trace amounts of radioactive elements.

BETA PARTICLE: Charged particle emitted from the nucleus and having a mass and charge equal in magnitude to those of the electron.

BETA RAY: A stream of beta particles, more penetrating but less ionizing than alpha rays; a stream of high-speed electrons.

BINDING ENERGY: The energy that holds the nucleus together, it is quantitatively related to the difference in mass of the separate component parts and the actual mass of the nucleus.

CALIBRATION: The measuring of the actual output of a machine as compared with its indicated or metered output.

CAPACITY: A general term referring either to the amount (maximum) of output a machine possesses or to the ability a device possesses to sustain a load.

CARCINOGENIC: Cancer producing.

CARDBOARD HOLDER: Referring to the exposure holder made of that material which acts only as a lightproof holder for x-ray film during exposure.

CASSETTE: Referring to the holder which is composed of two intensifying screens in a metal and bakelite holder.

CATHODE: The negatively-charged or filament side of a tube.

CATHODE "RAYS": The type of corpuscular energy consisting of a stream of electrons flowing from a negative potential toward a positive potential.

CELL: Structural unit of plants and animals. Cells are composed of a nucleus surrounded by cytoplasm.

CENTRAL RAY OR PRINCIPLE RAY (CR): The theoretical ray emitted from the exact geometrical center of the target at 90° to the long axis of the tube housing. The CR is directed through the part to be exposed to the center of the film.

CHEMICAL BONDS: The forces holding together the atoms of a molecule or chemical compound.

CHEMICAL FOG: An additional density occurring on a radiograph when the film has been stored in the presence of highly volatile gases or chemicals, from improper processing.

CHOKE COIL: A device usually used for regulating current in a circuit consisting of a coil of wire and a core which may be moved in and out of the coil. The device must be operated with an AC characteristic current.

CHROMOSOME: Component of cell nucleus concerned with transmittal of heredity.

COMPOUND: The union of two or more elements which may only be separated by chemical means.

COMPOUND MAGNET: A magnet formed by placing two or more single magnets together for the purpose of intensifying the lines of force.

CONDUCTIVITY: The quantitative ability of a material to conduct electric current.

CONDUCTOR: Any solid, liquid, or gas which readily allows the passage of electricity or heat through it.

CONE: A device used to reduce patient exposure and, thus, reduces secondary radiation.

CONTRAST: The difference in tonal values found on a radiograph.

CRINKLE MARKS: Artifacts resulting from rough handling of a film.

CYLINDER: A device used to reduce patient exposure, thus, reducing secondary radiation.

CURIE: Standard measure of rate of radioactive decay; the quantity of any radioactive nuclide in which the number of disintegrations per second is 3.700×10^{10}.

CURRENT: The flow of electrons from one place to another.

DECAY: Disintegration of the nucleus of an unstable element by the spontaneous emission of charged particles and/or photons.

DEFINITION: The relative sharpness of detail of a radiograph image due to the quantity of black metallic silver deposited in the emulsion.

DENSITOMETER: Instrument utilizing the photoelectric principle to determine the degree of opacity of developed photographic film.

DENSITY: The darkness of a radiograph.

DETAIL: The sharpness of internal structures on a radiograph. It is primarily due to geometric factors.

DEUTERIUM: A heavy isotope of hydrogen having one proton and one neutron in the nucleus. Symbol: D or ${}_1H^2$.

DIRECT CURRENT: The movement of electrons in only one direction.

DIRECT EXPOSURE EMULSION: A type of film coating reacting directly to the action of primary rays.

DIAPHRAGM: An accessory device which may be placed between or below the tube housing or which may be placed between the patient and the film, according to design; designed in any case to cut down effects of secondary radiation.

DISTANCE: The measurement of interval in arbitrary terms such as inches or centimeters.

DISTORTION: Any deviation from the normal. In radiography, true distortion is present when both shape and size are different from the object; false or magnified when only the size is changed.

DOSAGE (X-radiation): The total amount of radiation emitted from the tube and parts for a single exposure as measured in units called "rads" or "rems."

DOSIMETER: Instrument used to detect and measure an accumulated dosage of radiation; usually a pocket electroscope.

DOUBLE FOCUS TUBES: X-ray tubes with two filaments, hence, two actual focal spots.

DYNAMIC ELECTRICITY: Refers to electricity when motion is involved, such as in a circuit.

DYNE: A unit of force in the metric system; the amount of force that causes a mass at one gram to alter its speed by one centimeter per second for each second during which "X" force acts.

EFFECTIVE FOCAL SPOT: The focal spot at 90 degrees from the angle of approach of the electrons to the target.

EFFECTIVE CURRENT: The amount equal to .707 times the maximum current in an alternating wave which amount represents the amount of DC that would be necessary in that circuit to provide an equal amount of energy to it.

ELECTRICITY: Effect of electrons moving from one point to another.

ELECTROMAGNET: A device which consists of a coil and usually a core, and becomes a magnet when a current is sent through the coil.

ELECTROMAGNETIC INDUCTION: The process of inducing a current in a circuit due to changes in the electromagnetic field about a nearby circuit.

ELECTRON: The smallest particle of matter with a negative charge, which rotates in orbits around the normal atom.

ELECTRON VOLT: Amount of energy gained by an electron in passing across a potential difference of one volt. Abbreviated: eV. A million electron volts is abbreviated MeV.

ELECTROSCOPE: An instrument used to measure cumulative exposure to ionizing radiation.

ELECTROSTATIC UNIT OF CHARGE (esu): That quantity of electric charge which, when placed in a vacuum one cm distant from an equal and like charge, will repel it with a force of one dyne.

ELEMENT: A particular type of matter, all of whose atoms have the same chemical characteristics, such as copper, hydrogen, and lead.

ENERGY: The capacity or ability for doing work.

EXPOSURE DOSE: Quantity of radiation delivered to a certain place; usually measured in roentgens.

EXPOSURE HOLDER: Any lightproof container in which the film is placed during exposure.

EXPOSURE LATITUDE: The interval through which the primary factors of exposure may be varied, which would still yield the same effect, approximately.

FIELD: The area about a conductor through which passes the lines of force.

FIELD STRENGTH: Refers to the relative intensity of an electric or magnetic field.

FILM BADGE: Small piece of x-ray or similar photographic film enclosed in a lightproof paper usually crossed by lead or cadmium strips, carried in a small metal or plastic frame. The badge is used to estimate the amount of radiation to which an individual has been exposed.

FILTER: Any type of material which absorbs part of the softer x-rays which are emitted. Usually made of aluminum.

FFD: Abbreviation for "focal film distance." Distance between focal spot of the tube and the film.

FLUORESCENCE: The property certain substances have of emitting light when struck by x-rays.

FLUOROSCOPY: The term relating to all of the work done wherein a luminescent screen is used for viewing internal anatomy.

FORCE: The exertion of power in causing a person or thing to act, move, or comply against his or its resistance.

GAMMA RAY: Electromagnetic radiation emitted from the nucleus of a radioactive atom.

GENE: Chromosome component transmitting separate hereditary trait.

GENERATOR: A device which converts mechanical to electric energy.

GRID: A stationary or moving device which is placed between the part and the film to absorb secondary radiation.

GRID FOCUS: The point where all of the planes from all of the lead strips would meet.

GRID RADIUS: The perpendicular distance from the center of the grid to the point where the planes of all the lead strips would meet.

GRID RATIO: The ratio of the height of the lead strips to the distance between the strips.

HEAT DISSIPATION RATE: The rate at which heat is dissipated from a tube.

HALF LIFE: Time required for a radioactive substance to lose by decay 50 percent of its activity.

HARD RAYS: Those rays of a shorter wavelength, hence, more penetrating.

HELIX: A coil consisting of a single layer of turns.

HOT CATHODE TUBE: A vacuum-type tube using thermionic emission.

HU: Abbreviation for "heat units." Measurement of the heat produced during an x-ray exposure.

HYSTERESIS: Lag in the loss of magnetism by an electromagnet due to the continuous reversal of fields and forces.

IMAGE: The complete internal picture of the structure of the part.

IMPULSE TIMER: A particular type of timing device used for short exposures with intervals of 1/120 seconds and a range to only 1/5 second.

INDUCTION: The act or process by which an electric or magnetic effect is produced in an electrical conductor or magnetizable body when it is exposed to the influence or variation of a field of force.

INHERENT FILTER: That filtration which is part of an x-ray tube due to the materials used in construction.

INTENSITY: Specifically refers to amount or quantity of x-rays per unit.

INTENSIFYING SCREEN: Any screen which acts on the principle of fluorescence to emit an intense white light.

INVERSE SUPPRESSOR: A device to limit partially the reverse alternations of voltage effective upon the x-ray tube target.

ION: Atomic particle, atom, or chemical radical (group of chemically combined atoms) bearing an electrical charge either positive or negative, caused by an excess or deficiency of electrons.

ION CHAMBER: Container of gas in which an electric field exists because of a system of charged electrodes.

IONIZATION: Act or result of any process by which a neutral atom or molecule acquires either a positive or a negative charge.

IONIZATION CURRENT: The current which flows through an ionized gas.

ISOTOPE: One of two or more forms of an element having the same atomic number (nuclear charge) and, hence, occupying the same position in the periodic table.

JOULE: Electrical unit of work.

644

KEV (keV): Abbreviation for "thousand electron volts." See ELECTRON VOLT.

KILOVOLTAGE: Term used to refer to the amount of potential or electromotive force across a tube which determines the penetrating power of the x-rays that are emitted. By definition, kilovoltage is 1,000 times the push or pull on electrons that voltage is. Abbreviated kV.

KINETIC ENERGY: Energy in motion.

KVP (kVp): Abbreviation for "kilovolt peak" which is maximum kilovoltage in a given situation.

LATENT IMAGE: The invisible picture on a film before development and after the emulsion has been sensitized by the x-rays.

LABYRINTH: A maze constructed at the entrance of a darkroom for the purpose of making it light proof.

LD - 50: The dose of radiation at which 50 percent of a given species will die, usually within 30 days. Mean lethal dose.

MAGNET: A material usually containing iron and which possesses the property of attracting or repelling other similar substances by an invisible force. A magnet when freely suspended will line up in a north-south direction.

MAGNETIC FIELD: The area about a magnet or a conductor through which pass the lines of force (flux lines).

MA (mA): Abbreviation for "milliampere." One milliampere (mA) is equivalent to .001 of one ampere.

MAS (mAs): Abbreviation for "milliampere seconds." The product of milliamperes and seconds of exposure. Determines quantities of x-rays produced.

MASS: Quantity of matter; popularly thought of as identical to weight.

MATTER: Anything which occupies space and has weight.

MAXIMUM CURRENT: The value of current in an alternating wave of greatest magnitude. (Referred to as "peak current.")

MAXIMUM PERMISSIBLE DOSE: The amount of radiation which a normal human being may receive day in and day out without any harmful effects to himself becoming evident during his lifetime.

MEV (MeV): Abbreviation for "million electron volts." See ELECTRON VOLT.

MILLIAMPERAGE: The unit of current used to measure the quantity of electrons which flow across the x-ray tube. See MA.

653

MIXTURE: The physical combination of two or more elements which may be separated by physical means.

MOLECULE: The smallest particle of matter retaining all the physical and chemical properties of the original compound.

MUTUAL INDUCTION: The process whereby a current is caused to flow in one part of the circuit due to the fact that a current is flowing in another part.

NATURAL MAGNET: Any substance, such as magnetite, which occurs in a natural state and which possesses the properties of magnetism.

NEGATIVE CHARGE: Any group of electrons which builds up on the surface of a conductor.

NEGATIVE ION: An atom possessing a surplus of electrons.

NEUTRON: The smallest particle of matter possessing no electrical charges.

NUCLEAR ENERGY: The energy released by fission or fusion of atomic nuclei.

NUCLEAR FISSION: A special type of nuclear transformation characterized by the splitting of a nucleus into at least two toher nuclei and the release of a relatively large amount of energy.

NUCLEAR FUSION: Act of coalescing two or more nuclei.

NUCLEAR REACTOR: A device or machine for producing energy by fission or fusion of atomic nuclei.

NUCLEUS: Heavy central part of an atom in which most of the mass and the total positive electric charge are concentrated.

OFD: Abbreviation for "object film distance." Distance between the part being exposed and the film.

OHM (ohm): The unit of measurement of resistance.

OPTIMUM CONTRAST: That particular degree of contrast for a particular radiograph which reveals all of the finer internal structure of the part.

ORBITAL SHELL: An imaginary shell or layer in which the electrons travel about the nucleus of an atom. Each shell has a different energy value.

OVER-ALL STORAGE CAPACITY: The ability of the x-ray tube as a whole unit to withstand, store, and dissipate high amounts of heat.

OVEREXPOSURE: Film which possesses too much density, hence, which has a dark appearance.

PERIODIC TABLE: An arrangement of the chemical elements to show resemblances among them with respect to their chemical properties. In this table, the elements are arranged in rows by order of atomic number.

PHASE: The angular relationship or time relationship between the beginning of a wave or some other arbitratily selected point and any point on the same wave of the corresponding point on another wave.

PHOTON: A quantity of energy emitted in the form of electromagnetic radiation such as radio waves, light, x-rays and gamma rays.

POLARITY: Condition of being either positive or negative in relation to a magnetic pole.

POSITIVE ION: An atom with a deficiency of electrons, hence, positively charged.

POTENTIAL DIFFERENCE: Difference in potential between any two points in a circuit; caused by a lack of and an excess of electrons which are referenced to a common point.

POWER: The rate of doing work or equal to work divided by time.

PRE-READING METER: Any measuring instrument which is calibrated to read either a measurement in another part of the circuit or a reading before the current of voltage has actually begun to flow through the instrument.

PRIMARY RADIATION: The radiant energy which is directly emitted from the target of the tube.

PROTON: Nuclear particle with a positive electric charge equal numerically to the charge of the electron and having a mass of 1.007575 amu.

PULSATING DIRECT CURRENT: Electrons which continuously change speed and flow but not direction of flow.

RADIATION: Propagation of energy through space; an electromagnetic wave or rapidly moving atomic or subatomic particle.

RADIATION ABSORBED DOSE (rad): Quantity of energy absorbed by any substance.

RADIATION EQUIVALENT MAN (rem): That quantity of radiation of any type which when absorbed by man produces a biologic effect equivalent to that produced by the absorption of one roentgen of X- or gamma radiation.

RADIATION SICKNESS: The group of symptoms developed consequent to an over-exposure to ionizing radiation; symptoms include weakness, nausea, vomiting, diarrhea, leukocytopenia, anemia, and spontaneous bleeding.

RADIOACTIVITY: Process whereby unstable nuclei undergo spontaneous atomic disintegration with liberation of energy, generally resulting in the formation of new elements. The process is accompanied by the emission of one or more types of radiation such as alpha particles, beta particles, and gamma radiation.

RADIOISOTOPE: A radioactive isotope.

RECTIFIER: A device which allows current to flow in only one direction.

RESIDUAL MAGNETISM: The quantitative amount of magnetism left in a material after it has been removed from the presence of the magnet.

RESISTANCE: The tendency a circuit or conductor has of opposing the flow of current through it.

RETENTIVITY: The ability of a material to retain its magnetic phenomena once magnetized.

ROENTGEN: Standard unit of ahsorption of X- and gamma radiation in air: quantity of radiation needed. to ionize the atoms in one cubic cm of air.

SATURATION CURRENT: The maximum value of current which flows through the x-ray tube and which produces a specific amount of electrons according to the design of the tube and the materials of which it is built.

SATURATION VOLTAGE: That amount necessary to produce saturation current above which only the saturation current will flow.

SCATTERED RADIATION: A term generally used to indicate radiation produced from within the part itself by the action of primary radiation on the atomic structure of the part itself.

SCREEN FILM EMULSION: A film coating designed to react directly with the light from intensifying screen and only indirectly from the primary rays.

S (s): Abbreviation for "seconds of exposure."

SECONDARY RADIATION: That which is produced by the action of primary radiation of the atomic structure of the part, the table top, and the rays strike which does not absorb the energy.

SELF-INDUCTION: The tendency a change in the current relationship of a conductor has to affect the lines of force so that a counter emf is produced.

STATIC ELECTRICITY: Electricity at rest.

THERMIONIC EMISSION: The giving off of electrons by a wire which is heated.

TIMING CIRCUIT: That portion of an x-ray circuit which governs the total time in which the high voltage is applied to the tube.

TONAL VALUE: A given amount of density found in an area of a radiograph.

TONE: Ability of an image to transmit light.

TRANSFORMER: A device which operates on an AC characteristic current and changes a given input voltage and current to a different output voltage and current.

TRITIUM: An isotope of hydrogen having 1 electron, 1 proton, and 2 neutrons.

UNIDIRECTIONAL: Traveling in one direction only.

UNDEREXPOSED: A term referring to any radiograph which appears light in density.

VOLT: The unit of measurement of electrical force.

VOLTAGE: The electrical pressure, potential or electromotive force; push-pull on electrons.

X-RAY: A penetrating electromagnetic radiation similar to gamma radiation. This radiation is produced as a result of sudden decrease in electron energy.

TABLE OF CONTENTS

SECOND WEEK - PART II ONLY

SUBJECT PAGE

Weekly Objectives 1

X-Ray Tubes and Rating Charts 2

Exposure Arithmetic 12

Inverse Square Law 39

Primary Factors of Exposure 48

Accessory Devices 56

Radiation Protection 70

WEEKLY OBJECTIVES AND GOALS
SECOND WEEK - PHYSICS

By the end of the second week you will be tested on the following objectives. The examination will consist entirely of multiple choice items.

I. X-ray Tubes and Charts: (About 30% of the exam)

- A. State the requirements for x-ray production.
- B. Relate x-ray tube parts with their names, materials of construction and/or functions.
- C. From the Tube Rating and/or Tube Cooling Charts and a given exposure technique:
  1. determine whether a single exposure is safe.
  2. calculate the heat produced in a single exposure.
  3. calculate how many of these exposures may safely be made per minute.

II. Primary Factors of Exposure: (About 15% of the exam)

- A. Given any primary factor state how a change in that factor will affect any of the following:
  1. electrons crossing the tube.
  2. x-rays produced (quantity vs. quality; directly or inversely).
  3. x-rays reaching the film after penetrating a part (quantity and directly or inversely).
- B. Given a specific change in x-rays reaching the film (quantity and/or quality) state which primary factor was adjusted to cause the change.
- C. Given a control panel part state its function or when it operates.

III. Accessory Devices: (About 15% of the exam)

- A. State the use of filters and/or the minimum filtering required.
- B. Calculate the grid ratio when given specified grid dimensions.
- C. Compare grid efficiency with grid ratio.
- D. Describe proper grid usage to avoid grid lines and grid cut-off.
- E. Compare conefield size to radiation protection and fog control.

IV. Math: (About 25% of the exam)
Given specific x-ray exposures and using the appropriate formulas from memory calculate to find the unknown factor in any of the following formulas:

- A. mA x s = mAs (or equivalent formula)
- B. centimeters x .4 = inches
- C. $DCF \times ALD = DC \times FFD^2$ (or equivalent formula)
- D. $mAs_2 = mAs_1 \times \frac{FFD_2^2}{FFD_1^2}$ (or equivalent formula)

V. Review: About 15% of the exam will consist of review questions covering: Types of radiation, Electricity, x-ray production.

651

X-RAY TUBES AND RATING CHARTS

OBJECTIVES:

1. State:

   a. the three requirements for x-ray production.
   b. the relationships between the names of the tube parts, materials of construction and/or functions.
   c. the purpose of the Tube Rating Chart.

2. From the Tube Rating and/or Tube Cooling charts:

   a. determine whether a single exposure is safe.
   b. calculate the heat produced in a single exposure.
   c. calculate how many exposures may safely be made per minute (all formulas to be memorized).

A. Conditions (requirements) for X-ray Production

1.

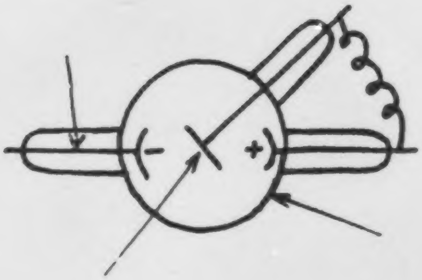
2.

3.

660

B. Gaseous Type X-ray Tube

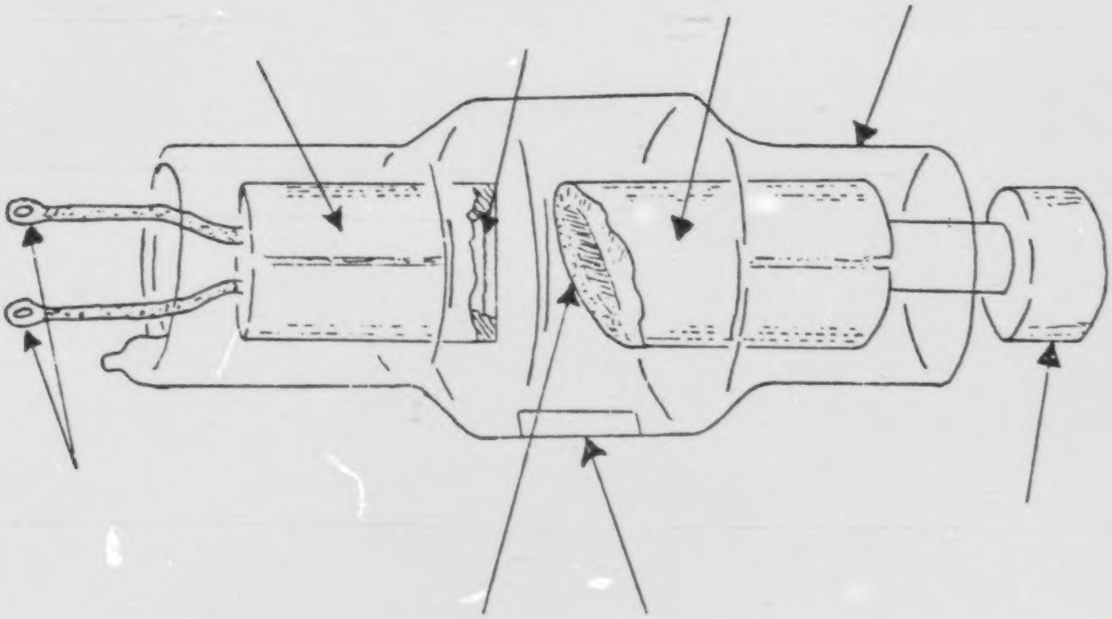
1. Construction



2. Operation

C. Hot Filament X-ray Tube (________________ Tube)

1. General construction

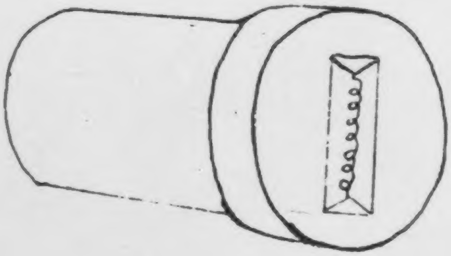


653

2. Tube Break-Down

a. Cathode

(1) Construction

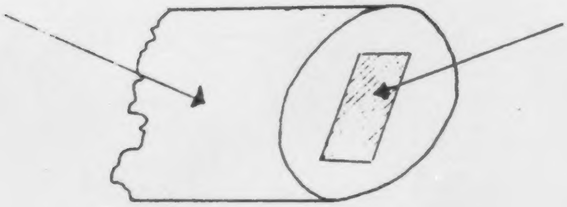


(2) Purpose (Function)

662

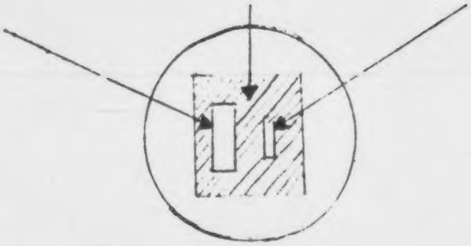
b. Anode

(1) Construction

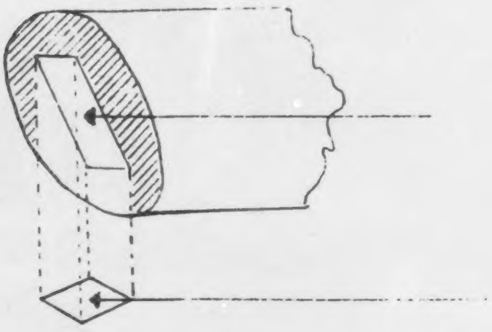


(2) Purpose (Function)

c. Focal Spot (Size)



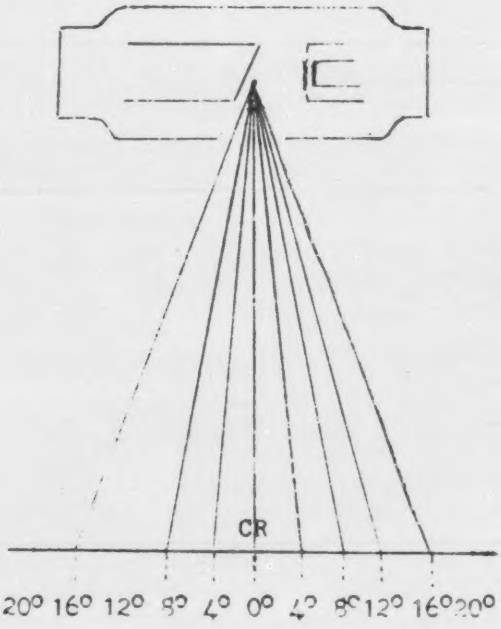
b. Line Focus Principle



D. Anode Heel Effect

1. Theory

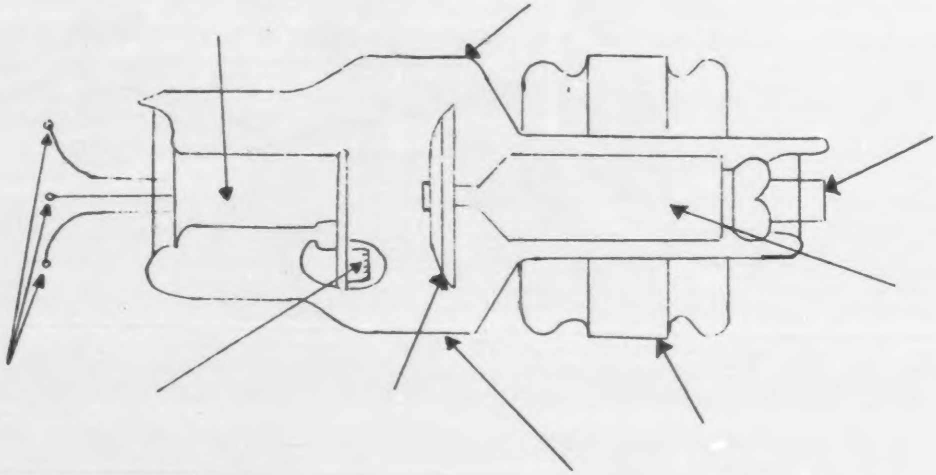
2. Illustration

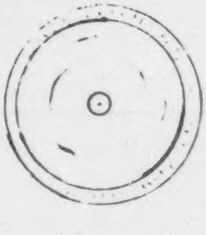

CR
20° 16° 12° 8° 4° 0° 4° 8° 12° 16° 20°

3. Application of Anode Heel Effect

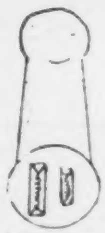
E. Rotating Anode Tube

1. Construction





Anode



Cathode

657

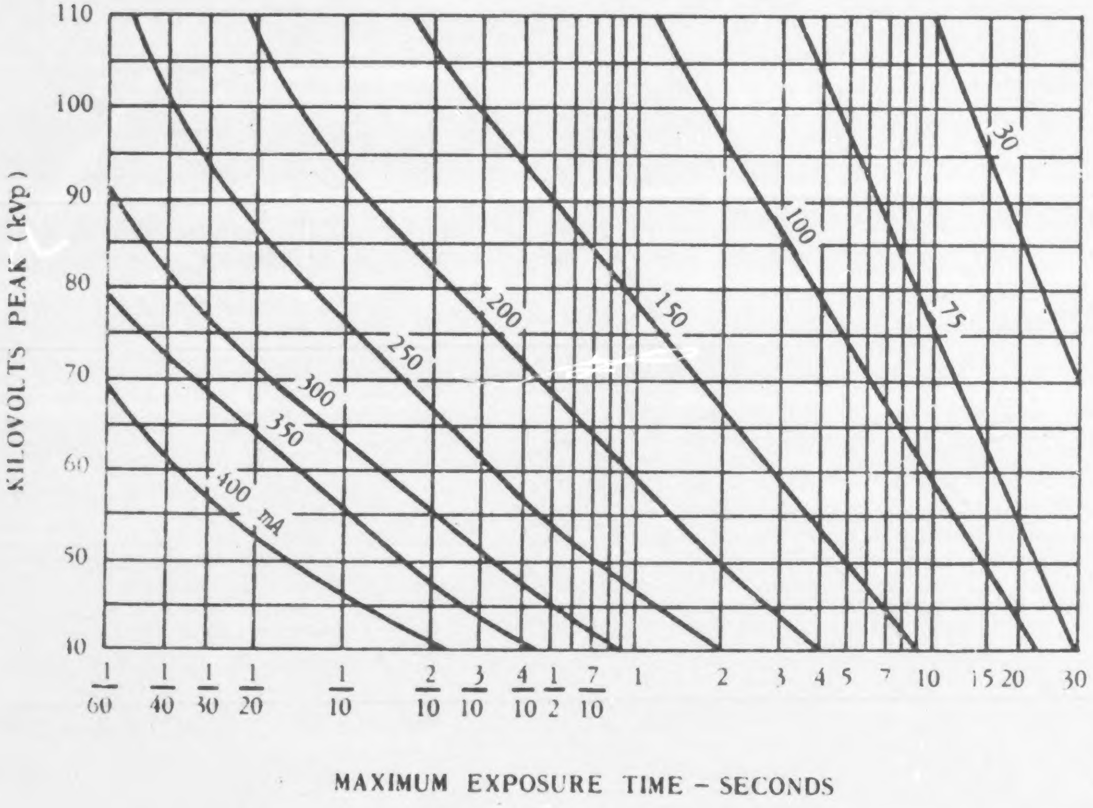
2. Advantages

f. Tube Rating Chart

1. Purpose

2. Application (Chart)

LARGE FOCAL SPOT



666

X-RAY TUBES AND RATING CHARTS

The x-ray tube is a man made device in which x-rays can be produced and controlled. The earliest x-ray tubes were gas tubes; difficulties were encountered in controlling the quality and quantity of the x-rays. In 1913, the modern x-ray tube was invented in the General Electric laboratories by Dr. W.D. Coolidge.

For x-rays to be produced, three conditions must exist. We must have a source of electrons, means of accelerating the electrons, and a means of suddenly stopping the electrons. To produce x-rays in any kind of a tube, we must fulfill these three requirements.

The source of electrons in the modern x-ray tube is a heated fine coil of tungsten wire called a filament. Whenever any tungsten wire is heated white-hot, it not only emits light but also causes electrons to be ejected from the surface. Electrons "boil off" forming a swirling negatively-charged cloud about the white-hot filament. If the filament cools somewhat, fewer electrons are liberated; if it is heated more, a greater number of electrons make up the cloud. The heat of the filament is controlled by the amount of electric current flowing through it. In short, the more current heating the filament, the hotter it gets and more electrons are liberated from the filament.

The electrons must then be speeded up to give them a large amount of kinetic energy (due to their speed). This is done by making the cathode filament negatively charged and the anode positively charged. The negatively-charged cathode filament repels the electrons with great force and the positively-charged anode attracts the electrons toward it with an equally strong force. The combination of "push" and "pull" on the electrons is measured in kVp and it speeds the electrons to a speed of about 60,000 to 90,000 miles per second. This gives the electrons a large amount of kinetic energy.

The kinetic energy of the high speed electron must be removed and changed into x-rays. Since the energy of the electrons is due to their high speed, if we suddenly stop the electrons, their energy is released. This released energy is the source of x-rays. Of all the energy of the fast-moving electrons, however, in even the best-designed x-ray tube, less than one percent is changed to usable x-rays--the remainder being dissipated as heat. Removing this heat from the anode is an important consideration in design and operation of x-ray tubes.

The problem of cooling the x-ray tube target is an important one from the standpoints of both design and operation. It is, however, the design of the x-ray tube that determines the limits of exposure. Even the tiniest bit more heat than the tube can withstand will impair its future operation. With a given design, the limits of tube exposure can be determined. These limits may be incorporated into charts for use by the x-ray technician. Although occasion to use these charts is relatively rare, the technician should recognize when these occasions arise so he can refer to the charts and recognize the operational limits for the x-ray tube.

The tube rating chart is used to determine whether any particular exposure is safe. Included on the tube rating chart are kVp, mA, and s. To determine the safety of any particular exposure, find the point of intersection of the kVp and s lines. If this point lies to the left and below the mA line to be used, the exposure is not likely to damage the tube. If, however, the point of intersection lies above and to the right of the mA line, tube destruction is almost certain. It should be noted that since a given mAs value may be arrived at by many combinations of mA and s, several possible different exposures may be used, some of which may be safe and some unsafe. In general, using higher mA values with shorter times will more likely produce unsafe exposures than lower mA with longer time to produce the same mAs. Note also that a tube rating chart is provided for each focal spot size. Naturally, the rating for a large focal spot is greater than that for a small focal spot on the same tube. Make certain you use the proper chart.

EXAMPLE: Using the large focal spot with 85 kVp at 150 mA and 2/10 s, we produce a safe exposure (intersection of 85 kVp and 2/10 s is below and to the left of 150 mA line). However, an exposure using 85 kVp at 300 mA and 1/10 s is unsafe (intersection of 85 kVp and 1/10 s is above and to the right of 300 mA line) eventhough both exposures produce 30 mAs and the same number of heat units.

Questions and Problems

Use the sample tube rating chart for the large focal spot and determine whether each of the following exposure is safe or unsafe.

	kVp	mA	s	Safe (yes or no)
1.	80	100	1/10	________
2.	75	300	2/5	________
3.	50	300	4/10	________
4.	95	100	1 ½	________
5.	65	250	1/2	________

BASIC MATH REVIEW

(& EXPOSURE ARITHMETIC)

OBJECTIVES:

Calculate from memorized formulas to find any of the following unknown factors:

1. mA, s, mAs.
2. centimeters, inches.
3. heat units.
4. DCF, ALD, DC, FFD.

A. Terminology

1. Subscript

a. Definition

b. Examples

2. Squaring

a. Definition

b. Examples

3. Ratio
    a. Definition

    b. Examples

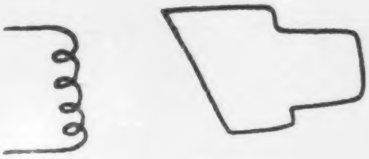
4. Proportion
    a. Definition

    b. Examples

5. Equations

B. mAs Formula

1. Theory



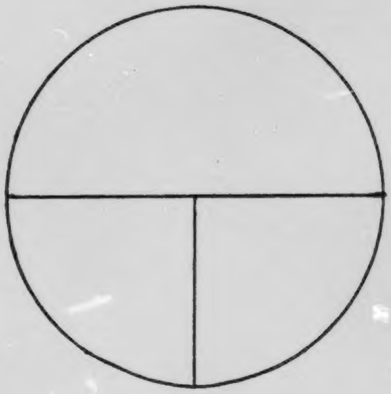
a. mA

b. s

c. mAs

2. Formula

3. Memory Wheel



4. Examples

5. Rounding Rules for mAs

   a. For mAs values LESS THAN 5 round off to the nearest ____________________

   b. For mAs values of 5 AND ABOVE round off to the nearest ____________________

4. Problems

	mA	s	mAs
a.	100	2	______
*b.	100	½	______
c.	20	3/4	______
d.	20	______	30
e.	50	______	10
*f.	4	______	2
g.	______	1/20	15
h.	______	2/5	20
i.	______	3/8	7½
*j.	100	______	30
k.	25	5/8	______

	mA	s	mAs
l.	25	________	1¼
m.	________	3/5	60
*n.	________	1/10	2½
o.	10	3/8	________
p.	20	________	7½
q.	________	1/10	5
*r.	________	4/5	40
s.	10	________	6¼
t.	________	3/4	15

E. Heat Units

1. Theory

NOTE: Heat units are electrically equivalent to watt-seconds.

2. Formula

3. Examples

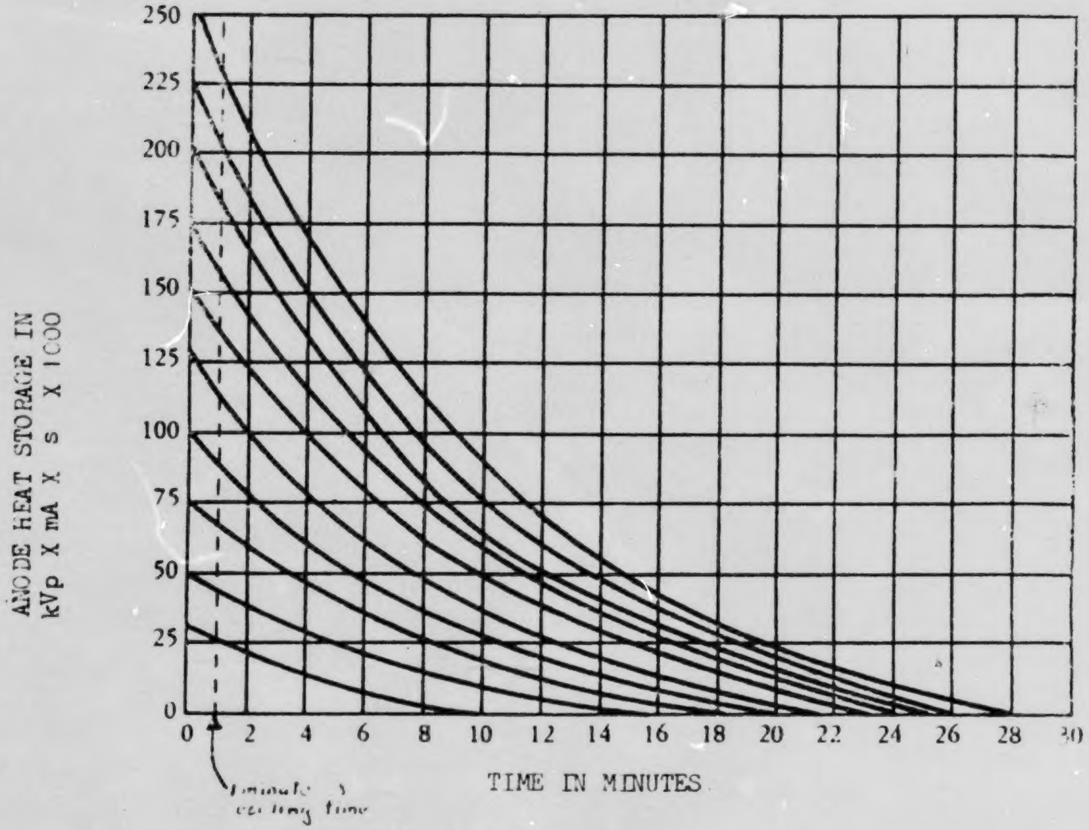
4. Problems

	HU	kVp	mA	s	mAs
a.		60	25	1/10	
*b.		85	50	3/5	
c.		75	50		25
d.		70	5		7½
e.		75		9/10	22½

	HU	kVp	mA	s	mAs
*f.		90		3/4	7½
g.		50	100	3/5	
h.		70	20	3/4	
i.		85	5	5/8	
*j.		80		3/8	7½
k.		85	10		50
l.		60	25		2½
m.		65		5/8	12½
*n.		50	100		20
o.		90		½	25
p.		70	4		3
q.		60	2½		1¼

	HU	kVp	mA	s	mAs
r.	________	70	20	________	12½
s.	________	65	________	½	12½
t.	________	80	________	3/10	15

5. Tube Cooling Chart



a. Calculation of MCR

Maximum Storage Capacity of Tube = HU

Heat Remaining After 1st Minute = - ______ HU

Heat Units Dissipated in 1st minute = ______ HU
(Maximum Cooling Rate = MCR)

b. Exposures Per Minute Formula (EPM)

c. Problems: Using a MCR of 25,000 HU/min calculate for each problem the heat units produced and the maximum number of exposures per minute which could be continuously produced without burning out the tube.

	kVp	mA	s	HU	EPM
1)	80	100	1/10	______	______
2)	75	300	2/5	______	______
3)	50	300	2/5	______	______
4)	95	100	1½	______	______
5)	65	250	½	______	______

d. In the problems in c, above would a single exposure be safe (refer to the Tube Rating Chart, page 8.)

1) YES NO

2) YES NO

3) YES NO

4) YES NO

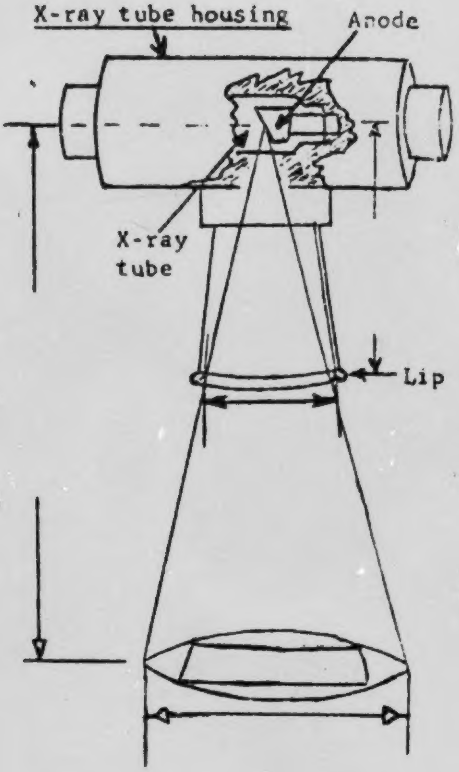
5) YES NO

(What conclusions can we draw from these results?)

671

F. DCF--ALD Formula

1. Theory


X-ray tube housing
Anode
X-ray tube
Lip

680

2. Equation

3. Application

4. Problems

	FFD	ALD	DCF	DC
a.	40	____	8	4
*b.	30	____	12	4
c.	48	____	12	4
d.	30	7½	____	3
e.	36	8	____	3
*f.	25	____	6	4
g.	48	2½	9	____
h.	30	3	14	____
i.	40	5	20	____

	FFD	ALD	DCF	DC
*j.	40	8½	________	4
k.	40	________	10	4
l.	60	2½	6	________
m.	72	2½	18	________
*n.	40	8	________	3
o.	36	________	9	4
p.	48	________	15	4
q.	30	8½	________	4
*r.	36	3	12	________

	FFD	ALD	DCF	DC
s.	60	9	________	4
t.	28	7½	________	3

684

EXPOSURE ARITHMETIC

FRACTIONS--A REVIEW

A fraction is a part of a whole number. The fraction $\frac{1}{2}$ has two parts.

The upper number is called the NUMERATOR; the lower number is called the DENOMINATOR; the horizontal line between the numerator and denominator means "numerator divided by denominator" or "1 divided by 2" in our example.

The DENOMINATOR of any fraction tells us into how many equally sized parts the whole number was divided. The NUMERATOR tells us how many of those parts we have.

There are two types of fractions: PROPER FRACTIONS (example: $\frac{3}{4}$) in which the numerator is smaller than the denominator and the value of the fraction is less than 1: and IMPROPER FRACTIONS (example: $\frac{4}{3}$) in which the value of the fraction is greater than 1.

In the x-ray course, we are not going to add or subtract fractions but multiplication and division of fractions will be common.

MULTIPLICATION OF FRACTIONS

Example: $\frac{3}{4} \times \frac{1}{2} = \frac{3 \times 1}{4 \times 2} = \frac{3}{8}$

RULE:
(1) Multiply the numerators to give the new numerator.
(2) Multiply the denominators to give the new denominator.
(3) Reduce if possible.

DIVISION OF FRACTIONS

Example: $\frac{25}{2} \div \frac{1}{4} = \frac{25}{\cancel{2}_1} \times \frac{\cancel{4}^2}{1} = 50$

RULE:
(1) Invert the divisor (that is the number AFTER the ÷ sign) and multiply.
(2) Follow all multiplication rules.

CANCELLING

Cancelling will greatly simplify your work IF you follow the rules of cancelling correctly. Many people cancel at the wrong times.

EXAMPLE A: $\frac{3}{\cancel{4}_2} \times \frac{\cancel{2}^1}{5}$ This is LEGAL! The answer is $\frac{3}{10}$.

EXAMPLE B: $\frac{\cancel{2}^1}{\cancel{3}_1} = \frac{\cancel{12}^4}{\cancel{18}_9}$ This is ILLEGAL! Note that the result says that $\frac{1}{1} = \frac{4}{9}$.

EXAMPLE C: $\frac{\cancel{2}^1}{\cancel{3}_1} \div \frac{\cancel{3}^1}{\cancel{4}_2}$ This is ILLEGAL! This would give an answer of 2 after inverting and multiplying. The correct answer is $\frac{8}{9}$.

The ONLY time we can cancel from the numerator to the denominator of different fractions is when the fractions are being multiplied. Note in EXAMPLE A we are multiplying so we can cancel.

In EXAMPLE B, two fractions are equal, NOT multiplied, and therefore, a wrong answer would result. In EXAMPLE C, we are dividing and we cannot cancel UNTIL we invert and multiply.

THINGS TO NOTE:

You can save yourself many incorrect answers by looking at the answer of a problem you have just worked and asking yourself, "Does this answer make sense?" Check these items to see if they do make sense.

1. Did you solve your problem by dividing the numerator BY the denominator?

   Example: $\frac{2}{3}$ is the same as $3\overline{)2}$ = .6666....

   Do not get in the habit of dividing the small number into the large one--sometimes that is not correct.

2. If you multiply by a fraction which value is less than 1 (a proper fraction) your answer will be SMALLER than your first number.

   Example: $20 \text{ X } \frac{3}{4} = \frac{\cancel{20}^{5}}{1} \text{ X } \frac{3}{\cancel{4}_{1}} = 15$ 15 is SMALLER than 20.

3. If you multiply by a number greater than 1 (an improper fraction) your answer is larger than your first number.

   Example: $50 \text{ X } 1\frac{1}{2} = \frac{\cancel{50}^{25}}{1} \text{ X } \frac{3}{\cancel{2}_{1}} = 75$ 75 is LARGER than 50.

4. If you divide by fractions, your results are opposite in size from what you got when multiplying.

   Example: $20 \div \frac{3}{4} = \frac{20}{1} \text{ X } \frac{4}{3} = \frac{80}{3} = 26\frac{2}{3}$

   Dividing by a proper fraction gives a larger answer.

   (Note the same figures are used in this example as in the example for multiplication by a proper fraction.)

   Example: $50 \div 1\frac{1}{2} = \frac{50}{1} \div \frac{3}{2} = \frac{50}{1} \text{ X } \frac{2}{3} = \frac{100}{3} = 33.333$

EXPOSURE ARITHMETIC

The heating effect on the target of the x-ray tube is dependent on three factors: (1) kVp, mA, and s. The kVp determines how "hard" the electrons are pushed, the speed, and the energy of the electrons and, thus, the amount of energy imparted to the target during exposure. The higher the kVp the more heat is formed. The mA is the rate of electron flow toward the target. Increasing the mA sends more electrons bombarding the target in the same length of time causing more heat. Increasing the mA increases the heat. Longer s means that electrons will hit the target for a longer period of time, thus, increasing the heat since sec is the duration of the electron flow.

The heating effect is measured in heat units. Heat units are calculated using the following formula:

$$HU = kVp \times mA \times s$$

There is a limit as to how many heat units the tube can withstand. This limit, along with how fast the tube can dissipate its heat, is included on the tube cooling chart. The tube cooling chart relates the heat stored in the tube to the cooling time. Referring back to the sample chart, if 125-thousand heat units were initially stored in the tube, approximately 100-thousand heat units would still remain in the tube after two minutes cooling time. (This assumes that: (1) the cooling system of the tube is working, and (2) no further x-rays are made during this time.) In other words, starting with 125,000 heat units, the tube will dissipate 25,000 heat units in two minutes.

The maximum cooling rate (MCR) is found by determining the amount of heat units dissipated in the first minute with the tube at its maximum heat storage (given at the top left of the chart). On our sample chart, the maximum heat storage is 250-thousand heat units. Then in one minute, the tube cools to about 225-thousand heat units. The MCR then is 25-thousand heat units per minute. This is the approximate MCR of most tubes cooled with liquid (oil)-air cooling systems.

The tube cooling chart is usually needed only when large numbers of exposures are made per minute for a fairly long period of time. The most common occasion for using the tube cooling chart is in mass chest surveys. For normal radiography the technician cannot produce exposures fast enough for the tube to become overheated. Even in mass chest surveys if the heat units produced are always less than MCR, the tube will never burn out from this cause. This can be insured by dividing the number of heat units for each exposure into the MCR. This will give the maximum number of exposures per minute of this kind that may be continuously permitted without burning out the tube.

As an example, the exposure using 85 kVp and 30 mAs produces 2550 HU. By dividing 2550 into 25,000 HU/min (the MCR) we find that a maximum of 9.8 exposures could be made per minute. Note that it does not quite come out 10. If no more than 9 exposures of this value are made per minute the tube will never become overheated. Also note that you cannot take part of an exposure without changing the exposure factors. The tube rating chart should be checked to see that each single exposure is also safe.

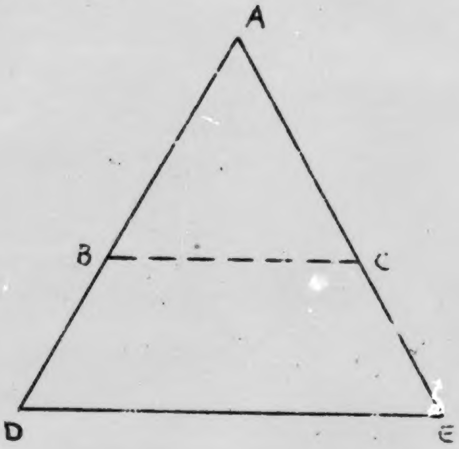
Physics is sometimes referred to as the "science of measurement." It follows that the language of radiographic physics is to some extent the language of mathematics. Hence, no clear understanding of roentgenography or of the x-ray machine operation can be had without some acquaintance with the elementary mathematical principles involved. The x-ray specialist will use simple mathematics in his work and must be accurate in his calculations, as you have already seen. The specialist should have some knowledge of fractions, decimals, exponents, elementary algebra, equations, ratios, and proportions, and the basic principles of geometry dealing with angles and rectangles. The subject of triangles will be briefly discussed here because the basic mathematical principles of triangulation are essential to a better understanding of the formation of roentgenographic images.

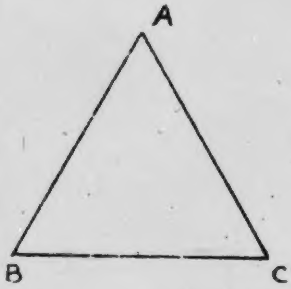
A triangle is a three-sided polygon. The perimeter of a triangle is the sum of the three sides. The area of a triangle is one half the base times the altitude. The altitude is the perpendicular distance from the apex to the base. When two triangles have the same shape but differ in size, they are known as similar triangles.

Of great importance in roentgenography is the relationship of similar triangles. In similar triangles the

corresponding sides are directly proportional. If line BC is drawn across the triangle ADE parallel with its base this line cuts off a triangle similar to triangle ADE. Two similar triangl

corresponding sides are directly proportional. If line BC is drawn across the triangle ADE parallel with its base this line cuts off a triangle similar to triangle ADE. Two similar triangles are seen on superimposed over the other. Line BC has been drawn parallel to the base DE, and triangle ABC is similar to triangle ADE and their corresponding sides are proportional. This type of problem is made simpler by mentally separating the two triangles. To understand the fundamentals of roentgenographic projections, foreign body localization, pelvimetry, body section roentgenography, unsharpness due to focal spot size, magnification, etc., a good practical working knowledge of the relationship of similar triangles is needed.





PROBLEM ANSWERS pp47-57
(unstarred problems only)

Section B, 4 (pp 17-19)
Problems:

a.	200 mAs	
c.	15 mAs	
d.	1½ s	
e.	1/5 s	OR .2 s
g.	300 mA	
h.	50 mA	
i.	20 mA	
k.	16 mAs	
l.	1/20 s	OR .05 s
m.	100 mA	
o.	3.8 mAs	
p.	3/8 s	OR .38 s
q.	50 mA	
s.	5/8 s	OR .63 s
t.	20 mA	

Section C, 4 (pp 20-24)
Problems:

a.	150 HU	2.5 mAs
c.	1875 HU	.5 s
d.	525 HU	1.5 s
e.	1688 HU	25 mA
g.	3000 HU	60 mAs
h.	1050 HU	15 mAs
i.	266 HU	3.1 mAs
k.	4250 HU	5 s
l.	150 HU	.1 s
m.	813 HU	20 mA
o.	2250 HU	50 mA
p.	210 HU	.75 s
q.	75 HU	.5 s
s.	813 HU	25 mA
t.	1200 HU	50 mA

Section C, 5, a (p 25)
Problems:

1)	800 HU	31 EPM
2)	9000 HU	2 EPM
3)	6000 HU	4 EPM
4)	14250 HU	1 EPM
5)	8125 HU	3 EPM

Section C, 5, b
Problems:

1)	YES
2)	NO
3)	NO
4)	YES
5)	NO

Section D, 4 (pp 29-31)
Problems:

a.	20	ALD
c.	16	ALD
d.	12	ALD
e.	14	DCF
g.	.47	DC
h.	1.40	DC
i.	2.50	DC
k.	16	ALD
l.	.25	DC
m.	.63	DC
o.	16	ALD
p.	13	ALD
q.	14	DCF
s.	27	DCF
t.	11	DCF

INVERSE SQUARE LAW

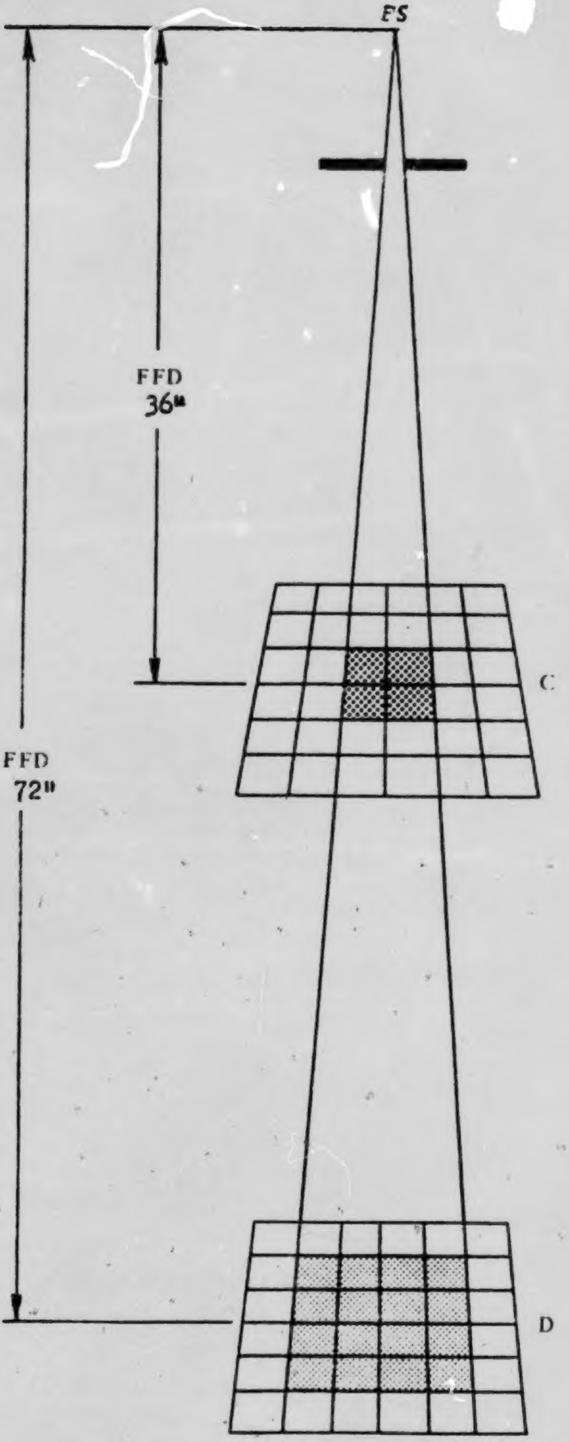
OBJECTIVES:

1. State how x-rays reaching the film are affected by a change in FFD.
2. Compute the new mAs required when changing from a given exposure technique to a new FFD.

A. Explanation

B. Application to X-ray

683


FS
FFD
36"
C
FFD
72"
D

Change in distance influences roentgenographic density.

684

C. Formula

D. Examples

E. Problems

	mAs$_1$	mAs$_2$	FFD$_1$	FFD$_2$
1.	10		40	25
*2.	5		40	30
3.	15		40	60
4.	40		36	30
5.	25		36	24
*6.	30		36	40
7.	5		30	25
8.	15		30	27
9.	2½		30	36

	mAs$_1$	mAs$_2$	FFD$_1$	FFD$_2$
*10.	60	________	60	48
11.	10	________	60	40
12.	15	________	60	30
13.	25	________	72	36
*14.	40	________	72	60
15.	150	________	40	25
16.	75	________	40	30
17.	10	________	36	48
*18.	20	________	36	25

687

	mAs_1	mAs_2	FFD_1	FFD_2
19.	15	________	30	40
20.	5	________	30	24

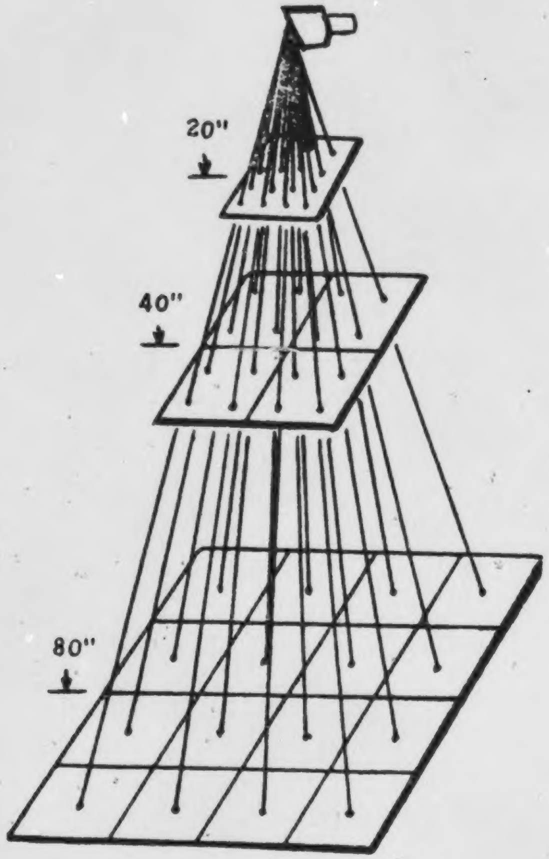
F. Things to Note About Inverse Square Law

696

688

INVERSE SQUARE LAW

X-ray films at different locations (distances) from the tube have different intensities of radiation. The figure shows films at 20" FFD, 40" FFD, and 80" FFD.



At 20" FFD, 16 x-rays are shown to strike the film.
At 40" FFD, 4 x-rays strike the same size area as at 20" FFD.
At 80" FFD, 1 x-ray strikes the same size area as at 20" FFD.

This relationship depends upon the squares of the FFD valvues. From 20" to 40" the squared ratio is:

$$\frac{20^2}{40^2} = \frac{400}{1600} = \frac{1}{4}$$

There are therefore 1/4 as many x-rays striking the same size film at 40" FFD as at 20" FFD.

From 20" to 80" FFD the squared ratio is:

$$\frac{20^2}{40^2} = \frac{400}{6400} = \frac{1}{4}$$

There are 1/4 as many rays striking the same size film at 80" FFD as at 40" FFD.

ANSWERS

section E. Problems

1. 3.9 mAs
3. 34 mAs
4. 28 mAs
5. 11 mAs
7. 3.5 mAs
8. 12 mAs
9. 3.6 mAs
11. 4.4 mAs
12. 3.8 mAs
13. 6 mAs
15. 59 mAs
16. 42 mAs
17. 18 mAs
19. 27 mAs
20. 3.2 mAs

PRIMARY FACTORS OF EXPOSURE

OBJECTIVES:

1. Define: Primary Factor.
2. State how a change in any primary factor will affect:
   a. electrons crossing the tube.
   b. x-rays produced (quality vs. quantity).
3. State the function of any item on the control panel of the typical x-ray machine.

A. Definition of Primary Factors

B. kVp - ______________________________

1.

2. Effect on Primary Beam

691

C. mA - ____________________

1.

2. Effect on Primary Beam

D. S= ______________

1.

2. Effect on Primary Beam

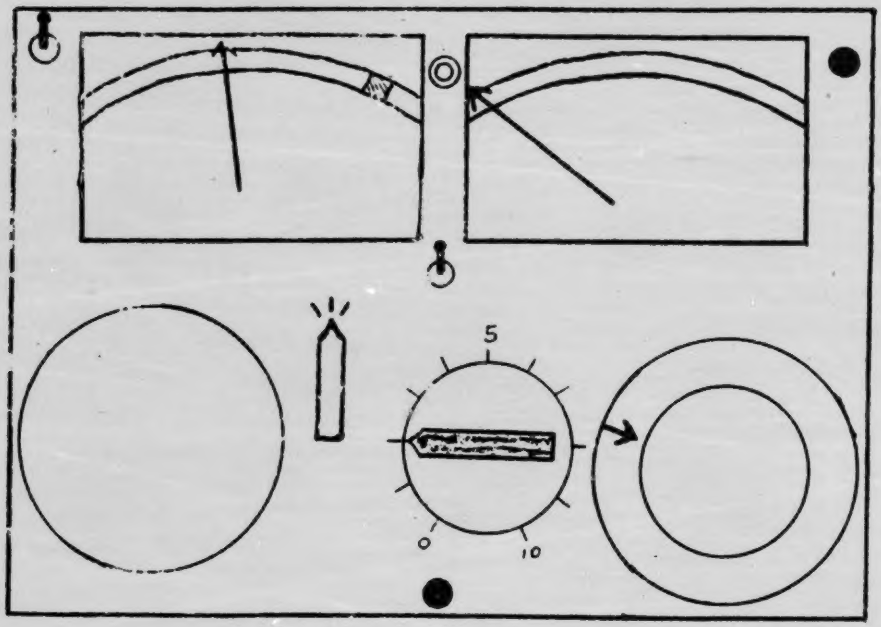
E. mAs - ______________________________

F. FFD - ______________________________

1.

2. Effect

G. Control Panel



694

H. Calibration of Equipment--List Steps

CALIBRATION CHART

Small Focal Spot: *

mA	5	10	15	20	25	30	40	50
Filament Check								

mA Large Focal Spot: *

	5	10	15	20	25	30	40	50
Filament Check								

PRIMARY FACTORS OF EXPOSURE

The control panel consists of controls and meterd usually all housed compactly in a separate, specially designed cabinet. The control panels on the different machines vary greatly in design and complexity, depending upon the size, capacity, purpose, and output of the machine. Certain basic elements of design are common to all.

Three meters are incorporated in many x-ray control panels. The milliammeter reads the value of the x-ray producing current passing through the tube from cathode to anode. The filament ammeter (filament check) measures the current used for heating the filament of the x-ray tube. The filament ammeter is usually found only in small portable machines. The kilovoltmeter indicates the voltage that will be applied (prereading voltmeter) to the x-ray tube when the exposure is being obtained.

The timer regulates the timing of the exposure so that x-rays will be produced for a limited period of time. The contactor, which initiates the exposure, is operated by a pushbutton switch through the timer.

There is also an "off and on" or main line switch situated in the control apparatus. When the main line switch is placed in the ON position, current enters the autotransformer and the KVp is indicated on the prereading voltmeter; the current flows through the filament of the x-ray tube and is indicated on the filament ammeter. When the main line switch is closed only the filament ammeter and the prereading voltmeter should give a reading. When the timer switch is closed, the current energizes the step-up transformer, which increases the voltage to kilovoltage, and the current emerging from the transformer passes across the x-ray tube. This current is read on the milliammeter. The only way of ascertaining whether x-rays are being produced is by observing an indicated current through the milliammeter. The milliammeter does not read a value until the contactor is closed.

It is necessary to have the circuit breaker in the closed position when an exposure is being made. The specialist should always check the position of the circuit breaker just before making an exposure.

Not all of the items mentioned above will be found as part of every x-ray machine control panel. The following modifications may exist.

The pre-reading voltmeter is omitted and a precalibrated kilovoltage selector control, which operates directly through the autotransformer, included. With this arrangement, it is necessary to have a compensator voltmeter and line voltage compensator on the control panel to enable the operator to correct for minor changes in line voltage.

A milliamperage selector switch is included in the control panel. In lieu of obtaining the desired mA by manually adjusting the choke coil for a predetermined filament ammeter reading, the mA for all operations is automatically controlled by means of the mA selector switch. The switch also automatically corrects voltage variations due to changes in the mA. On such switches, there are several precalibrated settings from which selection may be made. In general, the mA produced by this type of machine differ in steps of 25, 50, or 100. With each position selected, a definite mA will flow automatically in the x-ray tube (if the calibration is accurate.)

Often found on larger capacity machines is a mAs meter (ballistic mAs meter). Using high mA values and very short exposure times, the mA meter does not have the time for an accurate reading and, sometimes, may not even indicate an exposure. An accurate reading may be obtained by using the mAs meter. Associated with the mAs meter is a switch which must be depressed during the exposure when the mAs meter is used. The mAs meter should only be used when very short exposures are made.

QUESTIONS

Match the answers from Column A with the correct response in Column B. Answers from A may be used more than once. There may be more than one response for each question.

Column A

a. kVp
b. mA
c. s
d. FFD

Column B

_____ 1. Changes the quality of the primary beam.

_____ 2. Changes the quantity of the primary beam leaving the tube.

_____ 3. Has inverse relationship to the quantity of x-rays reaching the film.

_____ 4. Determines penetrating power of beam.

_____ 5. Doubling WHAT will double quantity of x-rays produced?

_____ 6. Doubling WHAT will have no effect on quantity of x-rays produced?

_____ 7. If quantity on the film quadrupled, WHAT factor has been halved?

698

ACESSORY DEVICES

OBJECTIVES:

State:

1. the purpose of filtration, types of filtration and minimum filtration required.
2. the purposes and/or functions of collimating devices.
3. the definitions of:
    a. grid ratio.
    b. grid focus.
    c. grid radius.
4. the relationship between grid efficiency and grid ratio.
5. the proper grid usage to avoid grid lines and grid cut-off.
6. the relative efficiency of collimation as compared to grids.

A. Definition

B. Commonly Used Devices

1. Sandbag

    a. Construction

    b. Purpose

2. Sandwich Board

    a. Construction

707

699

b. Purpose

3. Masks

4. Angliner

5. Angle Board

6. Calipers

7. Filters

   a. Construction

   b. Purpose

   c. Types

      (1) ____________________

      (2) ____________________

8. CR Stick

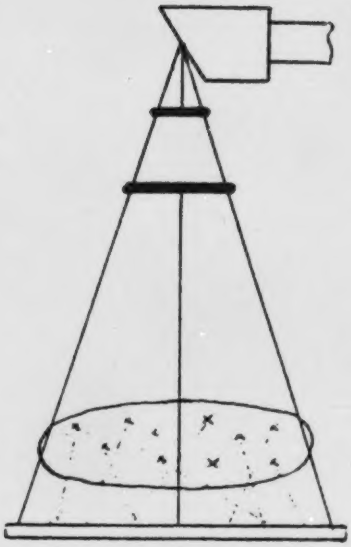
9. Others (Compression Bands)

10. Cones

a. Purpose

b. Types

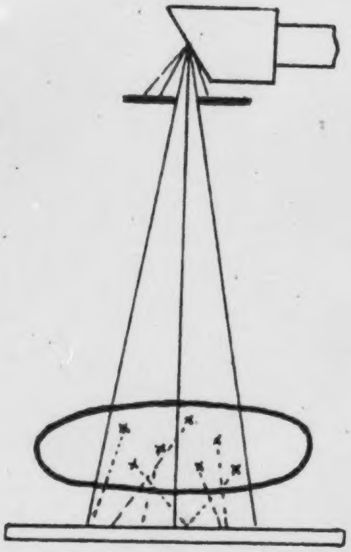
(1) **Flare Cone**



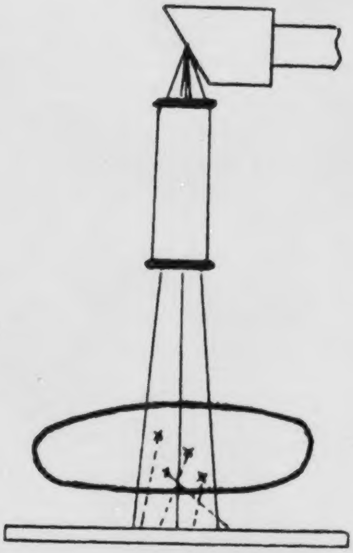
702

(2) Lead Diaphragm

(now obsolete)



(3) Extension Cylinder



711

(4) Collimator

11. Grids

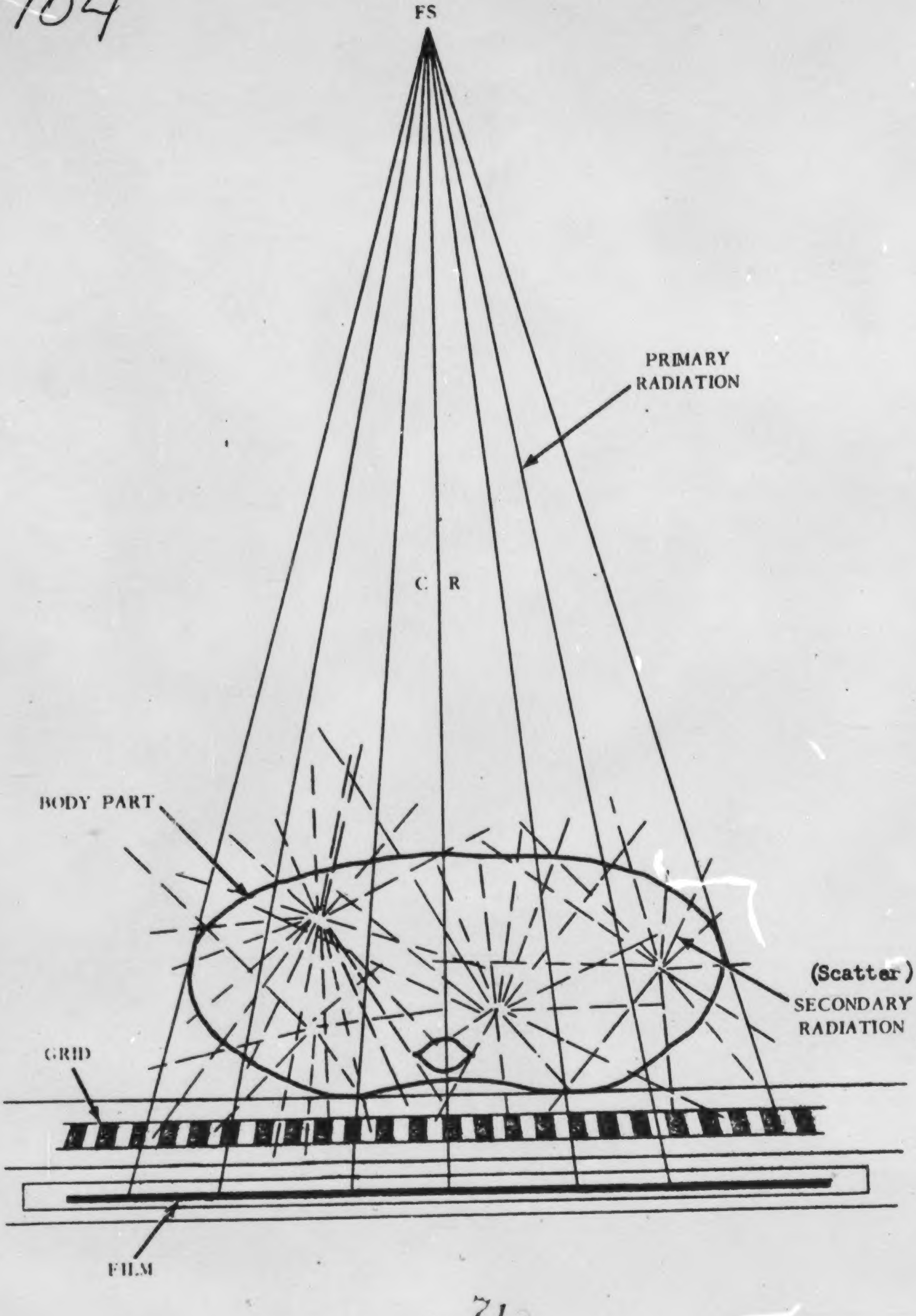
a. Purpose

b. Construction

c. Terminology

(1) Grid Ratio

704


FS
PRIMARY RADIATION
C R
BODY PART
(Scatter)
SECONDARY RADIATION
GRID
FILM

713

(2) Grid Focus

(3) Grid Radius

d. Stationary Grids

(1) Application

(2) Types

e. Potter - Bucky Diaphragm

706

f. Grid Cut-off

(1) Definition

(2) Causes

715

ACCESSORY DEVICES

There are four different cone-type devices. All of them work on the same principle - the outside portion of the x-ray beam is absorbed and prevented from reaching the patient. The smaller the beam of radiation striking the patient the less secondary radiation (SR) will be formed and the less fog will be produced on the film.

Since the smaller conefield also gives less radiation damage to the patient, SOME kind of cone device should be used on every exposure. The conefield should be reduced in size so as to only cover the film.

Cone-type devices other than the collimator do not show the the conefield size. Mathematical calculations may be made using the following formula:

$$DCF \times ALD = DC \times FFD$$

Where FFD is the focal film distance, ALD is the anode lip distance, DCF is the diameter of the conefield, and DC is the diameter of the cone.

When using the formula for a flare cone the factors are all known except for the DCF. With the extension cylinder the ALD may be changed and will be the unknown. With the diaphragm the DC will be unknown and represents the diameter of the hole to be cut in the lead.

The ratio of secondary radiation to remnant radiation emitted by thin parts is small, irrespective of the size of the field, because of the small amount of tissue irradiated. However, this does not hold true for the thicker and more dense structures. When the entire area of any film is to be exposed, it is necessary to use a cone, which, at least, restricts the diameter of the beam to equal the diagonal of the rectangular film.

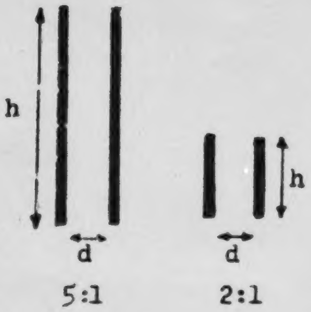
Secondary radiation is not only produced by the scattering of the primary beam by the atoms of the patient's body structures, but also by the beam passing through the top of the x-ray table. In passing through the body, the primary beam sets up numerous centers of secondary radiation throughout the irradiated part. The rays emitted from these centers within the body produce fog which covers the image on the film. The larger the volume of body tissue irradiated, the greater the fogging effect upon the film.

The function of the grid is to absorb SR emitted by body tissues before it reaches the film. Although all SR cannot be absorbed by the grid, it can be greatly reduced. The two types of grids most commonly used are the stationary wafer grid and the Potter-Bucky (P-B) grid diaphragm. The basic principle and structure are the same.

The stationary wafer grid is composed of alternate strips of lead and a radiotranslucent substance such as wood or a synthetic material. The strips are placed parallel to each other and form a very thin rectangular sheet the same size as the x-ray film. The grid is inserted between the patient and the film cassette so that the strips are lined up vertically beneath the patient's body. The primary radiation emitted from the focal spot of the tube passes between the lead strips to reach the film. Since the secondary radiation is unfocused and is emitted in all directions at all angles to the vertical, most of it strikes the lead strips and is absorbed, thus having little effect on the film. As much as 90% of the secondary radiation can be absorbed by the stationary wafer grid. The use of such a grid therefore greatly increases the diagnostic value of the roentgenogram because of the improved quality of the image. Although an image of the lead strips of the grid appears on the roentgenogram as evenly spaced thin white lines , they are not a disadvantage from the diagnostic standpoint. At the normal viewing distance of about 30 inches, the lines can seldom be seen. Normally, wafer grids are focused, that is, the lead strips are not parallel. Special care must be exercised in the use of this type of grid. If it is used at a very short FFD, the beam will be too widely divergent and the periphery (boundaries) of the roentgenogram will be underexposed because the outer rays will be absorbed by the lead strips. The beam must also be exactly perpendicular to the center of the grid, for if it is tilted across the length of the lead strips, more of the rays will be absorbed on one side than on the other and the edge of that side of the roentgenogram will be lighter.

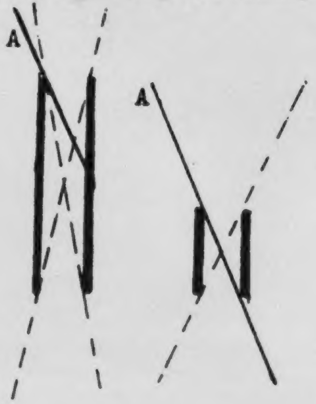
A grid cassette consists of a regular cassette (film holder) with a stationary grid built into the front. This is easier to use than a separate cassette and a stationary grid. The grid cassette produces grid lines as does the other set-up. Grid cassettes are identified by the orangish color of the front surface on the cassette. These cassettes must not be used in place of regular cassettes.

Grid ratio describes the efficiency of the grid in removing secondary radiation. This ratio is defined as being the height of the lead strips divided by the distance between them. Notice in the diagram that the higher grid ratio is more effective in reducing secondary radiation.



GRID RATIO

Grid ratio is height (h) divided by the distance between lead strips (d) or h:d.



LATITUDE OF GRID FOCUS

Effectiveness of the grid. Note that x-ray A can pass through the 2:1 grid but cannot pass through the 5:1 grid

Since most of the secondary rays are going at wide angles to the lead strips, higher grid ratios remove more secondary rays than lower ratios do.

Sometimes it is impossible to use the tube exactly at the grid focus. For practical application the FFD may be changed as much as 25% from the grid radius (for an 8:1 ratio grid or less; for higher ratio grids the problem rarely arises but if it does much less latitude than 25% is permissible depending on the exact ratio.)

The Potter-Bucky (P-B) diaphragm is a grid which moves across the film during the time of the x-ray exposure. It is placed between the patient and the cassette. The strips of lead and the wood composing the P-B diaphragm may be thicker than those of the stationary grids because the movement of the grid while the exposure is being made keeps the shadows of the lead strips from appearing on the roentgenogram.

The movement of the P-B diaphragm during the x-ray exposure is accomplished by a mechanism which moves the grid between the patient and the film. There are two general types of P-B diaphragms in use. The manual cock-type utilizes a spring which moves the grid across the film. Because the motion can be in but one direction and for only a limited distance, each time the grid is to be used the spring must be stretched by a cocking device and the grid held in place by a releasable catch. A hydraulic timing device is used to determine the speed of the grid motion. The speed should be slightly longer than the exposure time to insure motion of the grid during the whole exposure. The difference in grid time and exposure time should not be extreme, because if the grid moves too slowly the grid strips may remain in some areas for a longer period of time than in others. This will cause grid lines (shadows of the lead strips) to appear on the film. Just prior to exposure the grid is released by a manual or an electrical remote control switch. A bell is so placed as to ring upon completion of the grid motion. Ordinarily, the manual cock-type Bucky diaphragms should not be used for exposures shorter than 3/4 seconds.

The reciprocating grid utilizes an electric motor to move the grid back and forth above the film. The device that moves the grid is so designed that the time during which the grid stops at each end of its sweep is made as short as possible. No consideration need be given to the speed of the grid motion since that motion automatically starts at the beginning of the exposure and stops at its completion. Reciprocating grids may vary from one manufacturer to another; some have a grid speed that is identical in both directions, while others may have a slow sweep in one direction and a rapid sweep in another. Reciprocating grids may be used for exposures as short as 1/20 seconds, however, some high speed grids may be used for exposures of even shorter durations.

The appearance of grid lines on a film when the Bucky is utilized is usually caused by one of the following errors. The exposure is started before the grid is travelling at full speed. The exposure is prolonged after the grid has stopped moving or the movement has

711

slowed down. There is irregularity in the movement of the grid (may occur if anything rubs against the grid and restrains its motion.) The tube target is not aligned with the center of the diaphragm. There is synchronism between the movement of the grid strips and pulsations in the tube current. If the speed of the grid is such that succeeding lead strips are always above a given point on the film at the same instant that the pulsations of the current produce x-rays (when kVp is reached), images of the grid will appear on the film.

The Potter-Bucky diaphragm is especially useful in making roentgenograms of thick body parts.

720

RADIATION PROTECTION

OBJECTIVES:

1. State at least three ways of reducing radiation damage to each of the following: Patient, General public, X-ray technologist.
2. Calculate the Maximum Permissible Dose (MPD) for an X-ray technologist of a given age.
3. Given a list of body cell types, select the proper order of radiosensitivity from last to most sensitive.

A. Radiation

1. Definition

2. Sources of Exposure

B. Dosimetry

1. Definition

2. Most Common Units

a. Roentgen (r) -- (1928 & 1932)

713

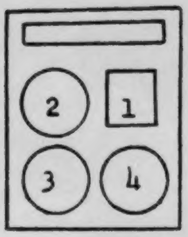
b. Radiation Absorbed Dose (rad) -- (1953)

c. Roentgen Equivalent Man (rem)

3. Monitoring Devices

    a. Photographic Film (Film Badge)

        1. Construction



        2. Usage

722

b. Ionization Chambers

c. Others

1) Thermoluminescence

2) Chemical Dosimetry

3) Calorimetry

4. Maximum Permissible Dose

a. Definition

b. Formula

MPD = (N - 18) x 5

AVERAGE EXPOSURE RATES PRODUCED BY DIAGNOSTIC X-RAY EQUIPMENT@

Distance from Source to Point of Measurement		Tube Potential						
		50 kVp	60 kVp	70 kVp	80 kVp	90 kVp	100 kVp	120 kVp
in	cm	Roentgens per 100 milliampere-seconds						
12	30	1.8	2.8	4.2	5.8	8.0	9.8	15.2
18	46	0.8	1.3	1.8	2.5	3.4	4.2	6.7
24	61	0.4	0.7	1.1	1.4	1.9	2.3	3.8
39	100	0.2	0.3	0.4	0.5	0.7	0.9	1.4
54	137	0.1	0.1	0.2	0.3	0.4	0.5	0.7
72	183	0.1	0.1	0.1	0.2	0.2	0.3	0.4

@ Measured in air with total filtration equivalent to 2.5 mm Aluminum.

This chart is from Table 6, Appendix B, p 44: NCRP Report No. 33, 1968.

716

RADIATION PROTECTION

Many of the pioneers of radiology received serious general and local injuries. From these early injuries an understanding evolved which led to the establishment of rules for protection against radiation. Today the harmful effects of ionizing radiation are well understood, and the means of protection are available. It is now possible to apply x-rays for diagnostic purposes with a very high degree of safety. This requires adequate room shielding, good equipment, and proper operating procedures. The last factor makes it particularly important for the x-ray specialist to understand the significance of protection.

The best information concerning protection in all fields of radiology is TB MED 62. Additional information on x-ray protection will be published by the National Council on Radiation Protection and Measurements, 4000 Brandywine St., N.W., Washington, D.C. 20016 in NCRP reports. The x-ray specialist should if possible read and understand the sections of these reports pertaining to his work and any special safety rules promulgated for his department. To eliminate the risk of overexposure, he must know the estimated safe limit of exposure to radiation. It is imperative that he adheres to the rules of safe practice in the performance of his duties. Carelessness will not be tolerated in an x-ray department.

Although the radiologist is responsible for radiation safety in his clinic, he can only provide the equipment required for protection. If the technician goes out of his way to keep from using this protection, the radiologist is not responsible.

There are no laws outlining the radiation responsibilities of the x-ray technician. These responsibilities are of a moral rather than a legal nature. The x-ray technician is morally responsible for the radiation safety to: 1) the patient, 2) the innocent bystander, and 3) himself. Since uninformed persons do not know the true nature of radiation hazards, the x-ray technician must take upon himself the radiation safety of all persons about him during an x-ray exposure.

725

The patient's exposure can be reduced by first of all a complete knowledge on the part of the technician of exposure factors to reduce retakes. Another means is the use of high kVp - low mAs techniques. Optimum kVp technique will in general use higher kVp than variable kVp. In coning down the x-ray beam you expose no more of the patient than is necessary for the examination. A final way of reducing patient exposure is the use of filters - 2mm added aluminum is required. The patient will receive approximately 30% less radiation using 3mm added aluminum filters. Film quality will not be impaired since no visible effect will be produced by the nonpenetrating, long wavelength x-rays anyway.

Exposure to the **general public** can be avoided by not permitting anyone in the exposure room during an x-ray examination. When someone is required to be in the room (to hold a child or some other patient) this person should be protected by a lead rubber apron and lead lined gloves. Persons who hold patients during x-ray exposure should not be called upon to do this with any regularity. This type of exposure should be spread about as evenly as possible among persons not occupationally exposed to radiation. Another good habit is to keep the doors from the exposure room to the patient waiting area closed during exposure. When bedside exposures must be made, do not allow curious individuals to crowd about the patient or machine. If practical, send patients in nearby beds away from the area during exposure, or use portable barriers.

Exposure to the x-ray technician can be reduced by first of all never holding a patient. Usually a relative or another patient can do this. Always stand behind a protective barrier during x-ray exposure. Make sure the room is set up safely. When making a portable radiograph stand as far away from the patient and the tube as possible during exposure and always wear a lead apron. Working in fluoroscopy again wear the lead apron. Also never stand next to the patient unless the particular examination being performed requires it. The safest position is behind the radiologist.

Radiation Protection: Specific Biologic Effects

I. OBJECTIVES

A. Given a situation, select the best method of radiation protection for each of the three categories of individuals who are exposed to radiation (i.e., the patient, the X-ray technologist, and the general public).

B. Given a list of cells, select the correct ranking of those cells in descending order of radiosensitivity.

C. State the concept of cumulative radiation.

D. State the difference between threshold and non-threshold doses.

E. List three factors which influence the amount of the effect produced by radiation.

F. List five effects of radiation on any type of cell.

G. Select four somatic effects of radiation.

H. Select the two components of radiation injury.

II. OUTLINE ON SPECIFIC BIOLOGICAL EFFECTS FROM RADIATION

A. Concept #1

Components of injury

a.

b.

B. Concept #2

1. Non-threshold dose
2. Threshold dose
3. Graphs

C. Three Factors that Influence the Amount of Effect Produced by Radiation

1.

2.

3.

D. Dose Rate

1.

2.

3.

E. Area of Body Exposed

1.

2.

F. Cell Sensitivity (Law of Bergonie and Tribondeau)

1.

2.

3. Relative radiosensitivity of cell types from greatest to least

a.

b.

c.

d.

e.

f.

g.

h.

i.

j.

k.

G. The Three Units - for Diagnostic X-Rays the Rad, Rem, and Roentgen Are Roughly Equivalent

H. Definitions

1. Acute exposure

2. Chronic exposure

3. Long term effect

4. Genetic effects

5. Somatic effects

I. Difficulty in Measuring Long Term Effects

1.

2.

J. Effects of Radiation On Cells

1.

2.

3.

4.

5.

K. Genetic Effects - Caused by Alteration of a Sperm or Egg Cell

1.

2.

3.

4.

5.

6.

L. Mutations

1.

2.

3.

M. Somatic Effects

1.

2.

3.

4.

N. Increased Incidence of Cancer

1.

2.

O. Effect on Developing Embryo

1.

2. Damage depends on amount and stage of pregnancy

a. First two weeks - outright death

b. Organogenesis state (2d - 7th week) - gross anomolies, i.e., gross structural damage, CNS damage

3.

a.

b.

c.

P. Cataracts

1.

2.

3.

Q. Life Span Shortening

1.

2.

R. Radiation Protection

1. Type of radiation present in exposure room

a.

b.

c.

2. Methods of protection

a. Patient

(1)

(2)

(3)

(4)

(5)

b. Members of the general public

(1)

(2)

(3)

(4)

(5)

c. X-Ray Technologist

(1)

(2)

(3)

(4)

(5)

(6)

(7)

(8)

Radiation Protection: Specific Biologic Effects

The X-ray technologist has a responsibility to understand the effects of radiation and protect all individuals from unnecessary X-ray exposures. There are many methods of radiation protection available for use. In today's society everyone is concerned with possible harmful biological effects from radiation exposure. Today, we will discuss the effects of X-rays in body tissues and methods to protect all individuals exposed to radiation.

The fact that ionizing radiation produces biological damage has been known for many years. It has only been within the last five years that the public has really been concerned with radiation damage, especially X-rays. Diagnostic X-rays contribute 66 - 90 percent of the total dose received by people yearly. As X-ray technologists, it is vital that you know the biological effects of radiation in order to protect yourself, the patient, and the general public. In addition, you will be the authority on radiation to the patient. Questions will be asked about adverse effects of radiation.

There are two general concepts about radiation that are important to understand. Concept #1 is: Radiation damage may be cumulative. There are two components to any radiation injury. Any radiation injury has a reparable and an irreparable component. From one acute exposure to radiation some damage will occur. Over time the injury will tend to repair itself, but will never reach the original condition. With multiple exposures, the irreparable component of the injury will continue to accumulate. Concept #2 states that any amount of radiation may produce some injury. This concept is a result of a controversy between two philosophies.

The non-threshold dose philosophy is that any amount of radiation can produce some effect. If we had sophisticated instruments, even low level effects could be detected. The threshold philosophy states that up to some point, a threshold, radiation injury is not caused. Beyond that point, damage may occur. Every effect would have a different threshold. There is supporting evidence for both philosophies. However, there is not enough evidence to say which philosophy is correct. In radiation protection we use the non-threshold philosophy since this places one on the safe side.

We will discuss three factors that influence the amount of the effect produced by radiation. The three factors are dose rate, area of the body exposed, and variation in the sensitivity of cells. The first of these factors is dose rate, that is, the amount of radiation delivered per unit of time. Generally, the faster the radiation is delivered, the greater the effect will be. Of course, the amount of time the radiation rate is delivered in will also influence the effect. Dividing the radiation dose into small fractions which are administered over a long period of time also tends to decrease the effect. The second factor is the area of the body exposed. In general, the larger the area of the body exposed, the greater the effect will be. This is one area where the X-ray technologist can really make an impact. Such actions as correct collimation and appropriate shielding can greatly reduce the area of the body that is exposed. This is also very effectively done in radiation therapy with the use of very large shields. The third factor, which has bearing on radiation damage, is the variation in cell sensitivity. Young, rapidly dividing cells which have not yet specialized are most radiosensitive. And conversely, those cells which do not reproduce rapidly and are highly specialized in function are most resistant to radiation. These two broad statements really summarize the law proposed by Bergonie and Tribondeau in 1906 which states: "The radiosensitivity of a tissue is proportional to its reproductive capacity and inversely proportional to its degree of differentiation." Based on this law, the various types of cells in the body can be ranked according to their sensitivity to radiation. Lymphocytes, erythroblasts, and myeloblasts, which are blood precursors, are the three most sensitive types of cells. Such cells as epithelial, endothelial, connective and kidney tubule cells are of intermediate sensitivity. Bone, nerve, brain, and muscle cells are least sensitive to radiation.

In order to intelligently discuss the specific effects of radiation, it is necessary to define some terminology. Two broad categories of exposure are acute and chronic exposure. Acute exposure is exposure to radiation over a period of time not to exceed 48 hours. It is usually a one-time exposure of radiation. Such exposures would usually result from accidents with radiation. Chronic exposure is exposure to radiation over a long period of time. One usually thinks of chronic exposure as occupational exposure. Also, the radiation dose is usually small. Examples of typical chronic exposures would be those exposures received by X-ray technologists and nuclear industry personnel. The reason for concern with chronic exposure is the possibility of damaging, long term effects.

The long term effect due to radiation in an increased risk of certain diseases or harmful conditions such as cancer or leukemia. Long term effects can be broken into two classes. The first class is genetic effects. A genetic effect results in a change in chromosomes of sperm or egg cells. This change is then exhibited in any offspring. The second class is somatic effects. Somatic effects are changes in the cells of the individual other than changes of the sperm or egg cell. The effect is oriented to that individual and is not passed on to any offspring. It is extremely difficult to measure long term effects. First, you must study large numbers of people. Second, long periods of time are needed for the study. The expenditures of time, personnel, and money make the study of long term effects difficult. Despite these problems, literature is full of long term studies on radiation effects. Many of these studies were done on animals. Some groups of people have been studied; such as, the Japanese survivors of World War II atomic blasts, radiologists, and individuals from accidents involving radiation.

There are five common effects of radiation on any type of cell. First, morphological changes can occur. If the cell shape is round, it would become elongated. Second, mutations could take place. These mutations might result in direct death of the cell. Third, a retardation of cell division could occur. Fourth, total inhibition of cell division is also possible. Fifth, abnormal cell division, which could result in explosive growth of cells, could occur.

Some genetic effects, which are caused by alteration of a sperm or egg cell, are: fetal loss, stillbirth, neo-natal mortality, congenital anomalies, newborn size, and sex ratio. Irradiation of the fetus during the first and second trimester can cause a condition called microcephally (small head). This condition can lead to mental retardation. Studies of the Japanese survivors of World War II atomic blasts showed that more females were born than males. Later, studies seem to indicate a shift to more females than males for all of Japan, so this data is suspect.

Mutations are caused by alteration in the genetic material of the cell. Radiation increases the mutation rate. Most mutations are harmful. If the mutation does not cause outright death, it may increase susceptibility to disease.

The somatic effects we will be concerned with are: increased incidence of cancer, effects on developing embryo, cataracts, and life span shortening.

Information linking X-rays with cancer is well known. Physicians working with X-rays before their harmful effects were understood are good examples. These individuals received very large cumulative exposures, particularly to the hands. As a result, many of them developed cancers in the exposed areas. During the period 1933 - 1942, one study found a 1.7 times greater incidence of leukemia among doctors than the general public. In 1952 another study found the incidence of leukemia among radiologists to be eight times greater than the general public.

Long term somatic effects to the developing embryo can occur. Several studies have demonstrated an increased risk of cancer and leukemia in children whose mothers received diagnostic X-rays to the abdominal or pelvic areas during pregnancy. This does not mean that a child who has been irradiated before birth will necessarily develop cancer. As a matter of fact, the probability is still very low. Damage depends on the amount and the stage of pregnancy. If the exposure occurs during the first two weeks of pregnancy, outright death of the fetus can result. If it occurs in the first or second trimester, particularly between the second and seventh week - the organogenesis stage, gross anomalies such as structural damage and CNS damage can occur. If it is known that the fetus has been irradiated between 1 - 10 rads, then this is grounds for an abortion. Certainly anything 10 rems to the fetus is definitely grounds for an abortion. Notice that these very important effects are produced early in pregnancy when the woman may have missed only one menstrual period and still may not know that she is pregnant. This poses a special problem to those of us who work with medical X-rays. How can we avoid unknowingly exposing a newly formed embryo? First, the physician who orders a pelvic, abdominal, or lower back X-ray examination on a woman should find out about the possibity of her being pregnant. If it appears that she may be pregnant, he should reconsider his need for X-rays. The patient should also take the initiative and tell her physician that she thinks that she might be pregnant. If the patient gets by the physician and the radiologist finds out that she is pregnant, he should then consult the physician and determine whether fewer views might be taken, shielding used, or the X-rays put off until after the child is born. If the X-rays are needed, with or without shielding, then it is up to the technologist to take special precautions. This includes collimation of the X-ray beam, use of shielding, setting the correct technique factors, and processing the film correctly to avoid retakes. Remember that every repeat film will expose the embryo or fetus to twice the original amount of radiation.

The third type of long term somatic effect from ionizing radiation is the induction of cataracts in the lens of the eye. When the lens is struck by radiation, the cells in the lens of the eye die. These cells remain and are not sloughed off; and if there are sufficient numbers of them, they can produce opacities which can interfere with vision. It is believed that large amounts of irradiation are needed to produce cataracts. Many studies are currently underway to study the effect of chronic exposure of X-rays in relation to cataract formation. Studies in mice show that as little as five rems can cause cataracts. During the next few years there are many studies underway which should yield more definitive results about the relationship between low level exposure and cataracts.

The fourth kind of somatic effect is life span shortening. Radiation is said to exert a non-specific life span shortening effect. By non-specific, we mean that it is a statistical phenomena. In order to observe any shortening of the life span, large numbers of experimental animals are irradiated at moderately high doses over long periods of time and on the average the irradiated ones died somewhat sooner. Life span shortening may be the result that the individual contacts cancer that he would not have, or it may be that he gets leukemia, or it may be just an increase in susceptability to other diseases. No life span shortening has been observed in medical X-ray personnel working at today's levels of permissible occupational exposure.

Several different types of radiation are present in the exposure room. There is primary radiation, leakage radiation, and secondary or scatter radiation. The primary beam, or useful beam as it is often called, is radiation which passes through the window, aperture, cone, or other beam limiting device of the source housing when the exposure switch or the timer is activated. Leakage radiation is all radiation coming from within the source of housing except the primary beam. Leakage radiation includes the portion of the radiation coming directly from the source and not absorbed by the source housing as well as the scattered radiation produced within the source housing. Scattered radiation is that radiation which during passage through matter has been deviated in direction. It may also have been modified by a decrease in energy. The scattered radiation is the result of Compton interactions. Secondary radiation is radiation that is completely absorbed during its passage through matter. The photoelectric effect is responsible for this kind of radiation. The low energy radiation given off as a result of this effect is immediately absorbed in the surrounding tissues. Many methods of protection from radiation are available. Some of the methods that are available are under the direct control of the X-ray technologists. There are three categories of individuals who are exposed to radiation: The patient, the X-ray technologist, and the general public. The best way to reduce exposure from radiation to the patient is to take the proper exposure the first time. Filtration of the primary beam is another way to reduce exposure to the patient. The filtration attenuates the low energy X-rays which cannot penetrate the film and only create more exposure to the patient. The use of high kV and low mAs techniques will reduce the patient exposure also. The use of good quality control on film development, as well as using correct technical factors, will alleviate the need for retakes and more exposure. Gonad shield should always be used when appropriate.

It should be pointed out that all of the methods that are available to protect the patient will also help protect the X-ray technologist. However, the primary means for protection of the X-ray technologist in a regular radiographic suite is the protective barrier. For fluoroscopy or when the X-ray technologist is using portable units on the wards, the primary means that the individual has for protection is the lead apron. For use of portables, distance is also an important factor. Any method that is employed to reduce scatter radiation will reduce the dose to the X-ray technologist. Such methods as, proper collimation, use of screens and grids, and proper design of the X-ray suite are all methods that can be employed. An X-ray technologist or anyone who is occupationally exposed to radiation should never hold a patient.

Many of the methods for protecting the general public are built in and not under the control of the X-ray technologist. By protecting the general public, we are speaking of individuals who may have an office next door or above or below the radiology suite or the patient who might be waiting outside the room. Such things as lead-lined walls and ceilings or floors are methods for protecting these individuals. However, there is another category for the general public. Many times, it is necessary for someone to hold the patient. Lead aprons and lead gloves should always be provided to individuals who are holding the patient. All unnecessary persons should be out of the radiology suite and the doors should be kept closed during X-ray examinations.

I would like to present you with two facts. First, human populations are being exposed to more and more X-ray procedures. Second, modern medical knowledge and techniques are saving more and more people with genetic defects. It is vital that you, as X-ray technologists, be aware of the biological effects of X-rays and the methods that you can use to protect yourself, the patient, and the general public from unwarranted exposures to radiation.

TABLE OF CONTENTS

FOURTH AND FIFTH WEEKS -- PART III ONLY

SUBJECT PAGE

Weekly Objectives, Week 4 1
Secondary Factors of Exposure 2
Compensation Factors 15
Radiographic Exposure Technique 31
Weekly Objectives, Week 5 40
Construction and Handling of X-Ray Film . 41
Film Holders and Hangers 50
Darkroom Construction 57
Darkroom Processing 63
Artifacts 71

WEEKLY OBJECTIVES AND GOALS
FOURTH WEEK - PHYSICS

By the end of the fourth week you will be tested on the following objectives.

1. Given any x-ray exposure technique and a change of any one of the Primary Factors, state whether (yes or no) and how (directly or inversely, if appropriate) each Secondary Factor will be affected by that change. (About 20% of the exam.)

2. Given any one of the Secondary Factors state whether each Primary Factor will affect that Secondary Factor and how (if appropriate, state whether the relationship is direct or inverse.) (About 20%)

3. Given a section of a typical Optimum kVp Technique Chart (taken from the chart on pp 131-134 of the GR) for reference and utilizing Compensation Factor formulas from memory, compute the new exposure, specifying the kVp, mA, s, mAs and FFD which will be used when making changes in any one or combination of up to three of the following situations for any given body part shown in the chart: (About 40% of the exam.)

   a. Patient Thickness is above or below normal range.
   b. Scale of Contrast is to be increased or decreased by either a drastic or moderate amount.
   c. Contrast is to be increased or decreased by either a drastic or moderate amount.
   d. The patient has a wet or dry cast on the part to be exposed.
   e. A change in grids is to be made to include any of the following:
      1) Change from any grid ratio (5:1, 6:1, 8:1, 12:1, 16:1) to a nongrid technique.
      2) Change from a nongrid to any grid ratio (see ratios above).
      3) Change from any grid ratio (see ratios above) to any other grid.
   f. FFD must be increased or decreased requiring a change in mAs.
   g. Age and physical condition (children, aged, bedridden) are not normal.

4. Identify the characteristics which best describe the theory of an Optimum kVp or Variable kVp Technique Chart.

5. Identify the advantages of Optimum kVp over Variable kVp techniques

6. Review: About 20% of the exam will consist of review questions which will relate the Secondary Factors to Accessory Devices which were studied in the second week.

731

SECONDARY FACTORS OF EXPOSURE

OBJECTIVES:

1. List the four secondary factors.
2. List the two auxiliary factors (OFD & FS) which affect secondary factors.
3. State which primary factor(s) affect(s) each secondary factor and fog and the relationships (direct or inverse) between them.
4. State how each secondary factor and fog is affected by any given primary factor.

A. Definitions

1. Primary Factors of Exposure--Review (see following page)

2. Secondary Factors of Exposure

3. Auxiliary Factors of Exposure

732

PRIMARY FACTOR REVIEW

See pp 73-75

	Electrons in Tube	X-rays produced	X-rays to film	Effect on film
kVp				
mA				
mAs				
s				
FFD				

B. ____________________

1. Definitions

2. Primary Factors Affecting ______________________

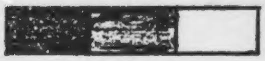
3. Auxiliary Factors Affecting ____________________

C. ____________________

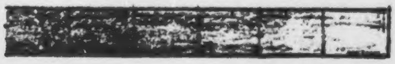
1. Definition

2. Types

   a. ______________________ - ____________ Scale



   b. ______________________ - ____________ Scale



3. Primary Factors Affecting ______________________

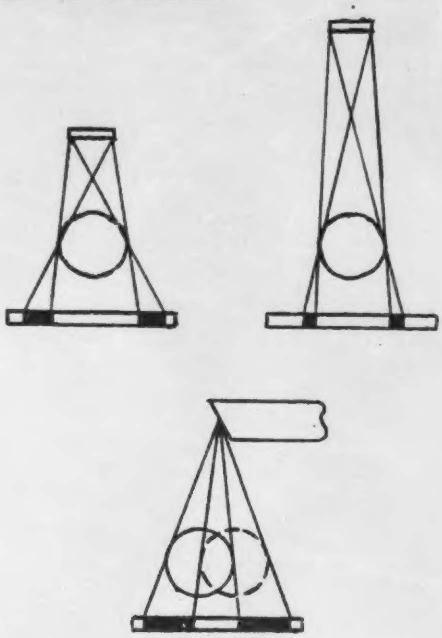
4. Auxiliary Factors Affecting ____________________

735

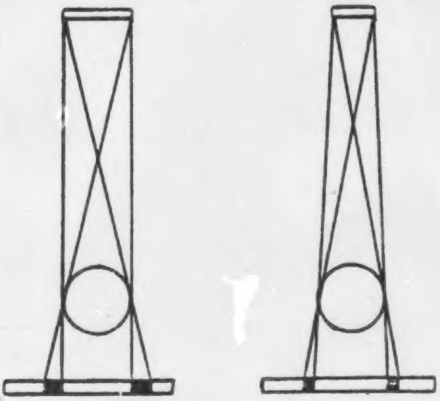
D. ____________________

1. Definition

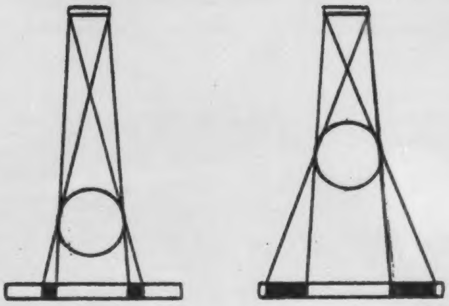
2. Primary Factors Affecting ________________



3. Auxillary Factors Affecting ______________



744



E. ____________________

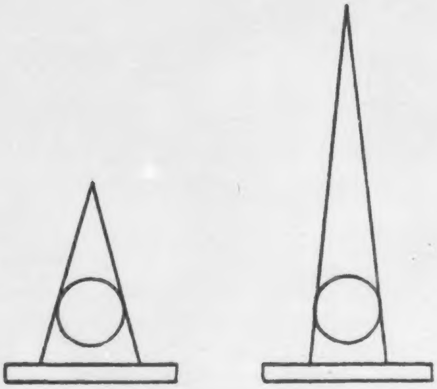
1. Definition

2. Types

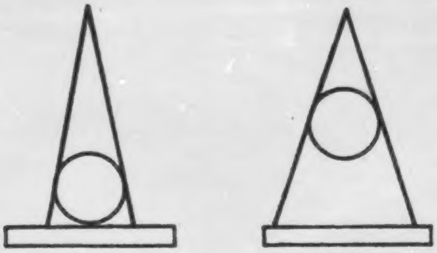
   a. ______________________

      (1) Explanation

      (2) Primary Factors Affecting ________________



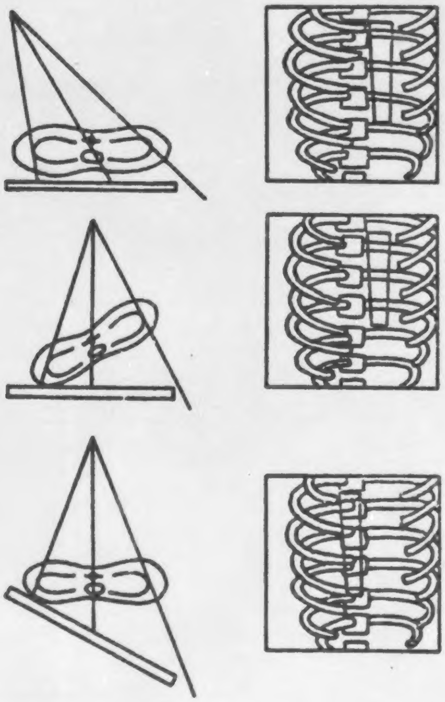
(3) Auxiliary Factors Affecting________________



b. ______________________________

(1) Explanation

(2) Auxiliary Factors Affecting________________



F. ______________

1. Definition

2. Primary Factors Affecting ______________

3. Auxillary Factors Affecting ______________

739

SECONDARY FACTORS AND FOG

					kVp	PRIMARY FACTORS
					mA	
					s	
					FFD	
					OFD (PFD)	AUXILIARY
					FS	

740

SECONDARY FACTORS OF EXPOSURE

The roentgenographic image is composed of many deposits of black metallic silver on both surfaces of the roentgenogram. These deposits blend into an image to represent the anatomical structures examined. The image has two major characteristics - density and contrast - directly influencing the diagnostic quality of the roentgenogram. Detail and distortion are also factors which aid in the overall quality.

Roentgenographic density refers to the amount of blackness on the film and is the resultant deposit of black metallic silver on an x-ray film after exposure and processing. The more silver that is present, the less light passes through the film and the more density we have. Anything that affects the number of x-rays reaching the film, will affect the density on the film. The more x-rays reaching the film, the greater the density.

Details of the tissue elements examined are rendered as densities of varying concentrations. During passage through a body part, the x-rays are absorbed by tissue components, resulting in a number of different silver deposits on the roentgenogram. The degree of silver concentration determines the brightness or tone value of the densities when viewed on an x-ray illuminator. The tonal relationship between one density and another enables image details to become visible. This is known as anatomical definition. The greater the number of tones present (correct tone rendition), the greater the number of structural details that can be visualized in the image. If the roentgenogram is processed by a standardized method, opaque silver deposits are known as over-exposures; areas of the image possessing little or no silver deposits are almost totally transparent and are known as highlights or under-exposures. The range of tones in an image is photographically known as the "gray scale."

Roentgenographic contrast exists when two or more roentgenographic densities are present. It provides differentiation between translucent roentgenographic densities to reveal all possible anatomical details when viewed on an x-ray illuminator. Note that the difference between the densities is called contrast. The greater the difference between the lightest and darkest part of the film, the greater is the contrast. Black against white is, for example, the highest possible contrast. If the darkest area on the film is a dark shade of gray and the lightest area is a light shade of gray, the difference between these areas is less, and we have lower contrast. The less difference, the less contrast. If there is only one density on the film there is no difference and no contrast.

Another set of terms which are usually used synonomously with high and low contrast is the concept of scale of contrast. The scale of contrast in a roentgenographic image is determined by the number and tone value of the various densities. Roentgenographic contrast may vary widely within some acceptable average range depending on the part being examined. A good roentgenogram possesses correct density balance over the entire contrast scale - good differentiation between tissue details of diagnostic interest without loss of detail in other areas of the image.

A short scale of contrast is impractical in medical roentgenography. In this type of contrast the range of image densities is short and small in number, each density exhibiting a large tonal difference from its neighbor. This number of densities is insufficient to portray a complete image of the subject. Roentgenographic details of an object cannot be seen in the image unless there are discernible differences in tone value between densities, and there must be a silver deposit on the film if a detail within the object is to be demonstrated.

A long scale of contrast is ideal for medical roentgenography. In this type of contrast the range of image densities is wide and great in number, each density exhibiting only a small tonal difference from its neighbor. The transition between tones is gradual, each tone is distinctive, and the image is completely informative. Desirable long scale contrast is produced to delineate all normal structures satisfactorily. In the case of human roentgenography when the scale of densities representing a departure from normal occurs, the image is open to suspicion from a pathologic or physiologic standpoint. The criterion of good diagnostic contrast is whether one sees all one expects to see.

The entire image exhibiting short scale contrast is invariably incomplete, for details representing the thinner and thicker portions of the body part are not always shown. Only those details in the image produced by exposure factors optimum for the area are rendered with maximum visibility. Short scale contrast is useful as a special procedure in more adequately visualizing details of small tissue areas and then only after preliminary survey films have been made.

Long scale contrast makes possible visualization of small variations of image densities. To obtain the maximum diagnostic information in the survey film, a compromise must be made between the roentgenogram with short scale contrast and that exhibiting the longer scale contrast.

Roentgenographic detail is the sharpness of the image on the film - a sharp image has good detail and an unsharp (blurred) image has poor detail. In referring to detail we will not be concerned with the visibility of the image. This is determined by the density and contrast. Since we have already covered density and contrast, we will consider only the factors which affect the sharpness of the x-ray image.

The information of the roentgenographic image is dependent upon geometric conditions associated with its projection. Actually, the image is composed of various details that are renditions of the anatomical structures through which the x-ray beam passed. These details are defined by various degrees of sharpness and shape, depending upon the geometric conditions. "Definition" describes the sharpness with which the detail is recorded. Roentgenographic details are never points in the image but are minute areas of black metallic silver.

Body parts are not always symmetrical since the body is an irregularly shaped object. Because of this, the roentgenographic image of a body part is sometimes misshapen, and the different portions of the area under exposure are not shown in correct relationship to each other. This untrue portrayal of the shape and/or size of a body part in a roentgenogram is called distortion. There will be a certain amount of distortion in every roentgenogram, since the film upon which the image appears has only one plane and the body part, or any other object being three dimensional , has many planes.

Distortion refers to a change in the image on the film. An image may be distorted in two ways: in size and in shape. Distortion in size always results since the x-ray beam must pass the part before it strikes the film. As the x-rays travel the added distance from the part to the film they continue their natural divergent path and strike an area on the film which is larger than the part being exposed. This type of distortion is called magnified (enlarged) distortion and is present on every radiograph. Distortion of the shape of the image on the film is termed true distortion. True distortion is caused by angling

743

the part, the tube, or the film. None of the primary factors affect true distortion.

Secondary radiation fog, a supplemental density, is a fairly uniform veil of silver overlying the image density produced by the primary beam. Caused by secondary radiation action, fog affects the visualization of detail and the quality of the image is degraded. By controlling the amount of secondary radiation reaching the film, details become more pronounced with the resultant improvement in image quality. In roentgenograms that exhibit secondary radiation fog the images have a dull gray appearance and lack important details.

Density is affected by all of the primary factors of exposure. Increasing the kVp increases penetration, which increases the number of x-rays reaching the film thus increasing density. Increasing mA also increases the number of x-rays to the film, increasing density. Increasing s will also increase the quantity of x-rays reaching the film therefore directly affecting density. Because of the inverse square law increasing the FFD decreases the number of x-rays reaching the film thus decreasing density.

Contrast is affected by only one primary factor--kVp. Increasing kVp decreases contrast and produces a longer scale of contrast.

Detail is affected by factors which control the geometry of the image formation. These factors are: focal spot size, FFD, OFD, and exposure time. The smaller the focal spot the better the detail. Increasing FFD also improves detail. Decreasing the OFD will improve detail too. Shorter exposure times are more likely to improve the detail because of the patient--motion problem which will blur the image.

Distortion is affected by factors which again affect geometry of image formation. Increasing the FFD decreases magnified distortion. Decreasing the OFD decreases magnified distortion. Angulation of the tube, part, or film causes true distortion which is a change of shape as well as size.

Compensation Factors

Objectives: Given a section of a typical Optimum kVp Technique Chart (taken from pp 35 - 38 of the GR) for reference and utilizing Compensation Factor Formulas from memory, compute the new exposure, specifying the kVp, mA, s, mAs, and FFD which will be used when making changes in any one or combination of up to three of the following situations for any given body part shown on the chart.

1. Patient thickness is above or below normal range.

2. Density: Given an underexposed or overexposed radiograph, adjust the technical factors to achieve a satisfactory density.

3. Contrast: Given a radiograph of satisfactory density:

    a. Scale of contrast is to be increased or decreased.

    b. Contrast is to be increased or decreased.

4. The patient has a wet or dry cast on the part to be radiographed.

5. A change in grids is to be made to include any of the following:

    a. Change from any grid ratio (5:1, 6:1, 8:1, 12:1, 16:1) to a nongrid technique.

    b. Change from a nongrid to any grid ratio.

    c. Change from one grid ratio to another grid ratio.

6. Age and physical condition (children, aged, bedridden, pathology) are not normal.

Part Thickness Compensations:

1. Application:

2. Compensation Factors

Chart Relating Adult Exposure
According To Part Thickness

Thickness Range	BELOW		NORMAL	ABOVE	
	3 - 5 cm	1 - 2 cm	In Range	1 - 2 cm	3 - 5 cm
Compensation			Basic mAs*		

*For compensations above and below range, the change in mAs may be made by changing either mA or s. In practice, these changes are usually made in s only. For above range parts, it would be desirable to make the changes in mA if this is possible (e.g., if such a setting exists) without going to a larger focal spot so we can use a shorter exposure time. In a normal situation, the change ordinarily must be made in s.

3. Problems

a. Given: 80 kVp, 50 mA, ½ s, 40" FFD
Average Thickness--12 to 15 cm

*(1) Patient measures 2 cm below range.

________kVp ________mA ________s

(2) Patient measures 18 cm.

________kVp ________mA ________s

*(3) Patient is 1 cm above range.

________kVp ________mA ________s

b. Given: 75 kVp, 30 mAs
Average Thickness--10 to 14 cm

*(1) Patient measures 6 cm.

________kVp ________mAs

(2) Patient is 2 cm above range.

______kVp _______mAs

Density:

1. Application:

2. Compensations:

Chart relating kVp to density

1/2 Density	Original Density	Double Density
	kVp used	

Normally, the best way to correct the density of the radiograph is in mAs.

Chart Relating mAs to Density

1/2 Density	Original Density	Double Density
	mAs used	

NOTE: A 20% change in the mAs will make a noticeable change in the density. To get a satisfactory density on the film, the following steps are necessary.

1. For overexposure

   a.

   b. Make minor adjustments between to achieve satisfactory film.

2. For underexposure

   a.

   b. Make minor adjustments between to achieve satisfactory film.

747

3. Problems

a. The quality control technician has just returned a radiograph to you and told you that it is too dark. The position is an AP pelvis. The technique used was 70 kVp, 300 mA, 2/5 s, 40" FFD.

*(1) What technique will you use to obtain a lighter film?

kVp mAs

(2) The repeat is a little too light, make a minor adjustment for greater density.

kVp mAs

b. An AP shoulder taken at 70 kVp, 200 mA, 1/10 s is too light.

*(1) What technique will you use to compensate?

kVp mAs

(2) The second film is slightly too dark, make a minor adjustment in density.

kVp mAs

c. A transthoracic humerus was taken at 90 kVp, 200 mA, 1/2 s, 40" FFD.

*(1) The film is too dark, compensate.

kVp mAs

(2) The second film is too dark, compensate

kVp mAs

*(3) The third film is too light, make a minor adjustment to the density.

kVp mAs

(4) The film is still too light, make a minor adjustment to the density.

kVp mAs

d. A PA hand was taken at 50 kVp, 25 mA, .05 s, it is too dark. No lower machine adjustments can be made in mAs.

*(1) What technique will you use?

kVp mAs

756

B. Contrast

1. Types - Review

a. High Contrast - ___________Scale

b. Low Contrast - ___________Scale

2. Application

3. Compensation Factors

**Chart Relating Contrast Changes
Keeping Density Constant**

Lower Contrast (Longer Scale)	Higher Contrast (Shorter Scale)
1.15 x kVp	.85 x kVp
1/2 x mAs	2 x mAs

NOTE: The above chart expresses the 50/15 rule for changes in contrast which states that to change the contrast while maintaining the density, the kVp is changed by a factor of 15% and the mAs is either 50% or doubled.

4. Problems

a. Given: 70 kVp, 30 mAs, 40" FFD

*(1) Produce a shorter scale of contrast
kVp mAs

(2) Produce a higher contrast
kVp mAs

*(3) Produce a lower contrast
kVp mAs

*(4) Produce a longer scale of contrast
kVp mAs

b. Produce greater contrast with each of the following exposures:

*(1) 80 kVp, 100 mA, 3/10 s, 40" FFD
kVp mAs

(2) 60 kVp, 50 mA, 3/20 s, 36" FFD
kVp mAs

*(3) 75 kVp, 25 mA, 1/5 s, 40" FFD
kVp mAs

(4) 90 kVp, 5 mA, 1/2 s, 30" FFD
kVp mAs

c. Produce a longer scale of contrast with each of the following exposures:

*(1) 60 kVp, 100 mA, 3/20 s, 30" FFD
kVp mAs

(2) 75 kVp, 50 mA, 3/10 s, 40" FFD
kVp mAs

(3) 90 kVp, 25 mA, 1/5 s, 30" FFD
kVp mAs

(4) 80 kVp, 5 mA, 1/2 s, 40" FFD
kVp mAs

C. Casts

1. Application

2. Compensation Factors

Chart Relating Changes In
Exposure Because Of Casts

Dry Cast	OR
Wet Cast	OR

NOTE: A wet cast is one that is less than _______ hours old.

NOTE: All changes in exposure to compensate for casts will be made in ______ unless the resulting exposure cannot safely be used on the particular machine in use. Only then should the ____ be changed.

3. Problems

a. Compensate for a dry cast in each of the following exposures. Assume a safe limit of 90 kVp.

*(1) 70 kVp, 20 mAs, 40" FFD

_____kVp _____mAs

(2) 80 kVp, 10 mAs, 30" FFD

_____kVp _____mAs

*(3) 60 kVp, 15 mAs, 36" FFD

_____kVp _____mAs

(4) 75 kVp, 2.5 mAs, 40" FFD

_____kVp _____mAs

*(5) 65 kVp, 12.5 mAs, 30" FFD

_____kVp _____mAs

b. Compensate for a wet cast in each of the following exposures. Assume a safe limit of 90 kVp.

(1) 75 kVp, 15 mAs, 36" FFD

____kVp ____mAs

*(2) 60 kVp, 10 mAs, 40" FFD

____kVp ____mAs

(3) 80 kVp, 2.5 mAs, 30" FFD

____kVp ____mAs

*(4) 70kVp , 20 mAs, 40" FFD

____kVp ____mAs

(5) 65 kVp, 25 mAs, 30" FFD

____kVp ____mAs

D. Grids

1. Application

2. Compensation Factors

Chart Relating Changes In
Exposure Because Of Grids

Type of Grid	From Nongrid To Grid	Removing Grid
5:1		
6:1		
8:1		
12:1		
16:1		

NOTE: All changes in exposure to compensate for grids will be made in _____ unless the resulting exposure cannot safely be used on the particular machine in use. Only then should the _____ be changed.

3. Problems

a. Compensate as indicated for the following exposures. Assume a machine limit of 95 kVp.

*(1) 50 kVp, 10 mAs, nongrid--change to--5:1 _____kVp _____mAs

*(2) 75 kVp, 5 mAs, nongrid--change to--8:1 _____kVp _____mAs

*(3) 80 kVp, 25 mAs, 8:1 --change to--nongrid _____kVp _____mAs

(4) 60 kVp, 15 mAs, nongrid--change to--5:1 _____kVp _____mAs

*(5) 65 kVp, 40 mAs, 5:1--change to 8:1 _____kVp _____mAs

(6) 85kVp, 7.5 mAs, 16:1--change to--5:1 _____kVp _____mAs

b. Compensate ONLY as indicated for the following exposures. Assume a machine limit of 95 kVp.

*(1) 70 kVp, 10 mAs, 8:1--to--nongrid and wet cast _____kVp _____mAs

(2) 60 kVp, 25 mAs, 5:1--to--16:1 _____kVp _____mAs

(3) 50kVp, 5 mAs, nongrid--to--16:1 and dry cast _____kVp _____mAs

*(4) 80 kVp, 15 mAs, 8:1--to--5:1 and dry cast _____kVp _____mAs

*(5) 50 kVp, 10 mAs. nongrid--to--8:1 _____kVp _____mAs

*(6) 75 kVp, 5 mAs, nongrid--to--16:1 _____kVp _____mAs.

*(7) 80kVp, 25 mAs, 8:1--to-5:1
_____kVp _____mAs

(8) 60 kVp, 15 mAs, nongrid--to--dry cast
_____kVp _____mAs

*(9) 65 kVp, 40 mAs, 5:1--to--wet cast
_____kVp _____mAs

(10) 85 kVp, 7.5 mAs, 16:1--to--5:1 and dry cast
_____kVp _____mAs

*(11) 70 kVp, 10 mAs, 8:1--to--5:1 and wet cast
_____kVp _____mAs

(12) 60 kVp, 25 mAs, 5:1--to--16:1 and dry cast
_____kVp _____mAs

(13) 50 kVp, 5 mAs, nongrid--to--16:1 and wet cast
_____kVp _____mAs

*(14) 80 kVp, 15 mAs, 8:1--to--16:1 and wet cast
_____kVp _____mAs

E. Miscellaneous (Age, Physical Condition, Pathology):

1. Children

a. Application: Technique charts do not always have the technique for children written on them.

b. Compensation Factors

Chart Relating Changes in Exposure Because of Age

Age	Factor
0-1 Years	
2-4 Years	
5-12 Years	

2. Elderly

a. Application: As our age advances into the "twilight" years, our bodies begin to metabolically deteriorate, muscles atrophy and bones decalcify.

b. Compensation Factors: Aged individuals from about 55 years of age may require a reduction of exposure of to the normal adult exposure, depending upon the body aging conditions. (Patients bedridden over six months require basic mAs.)

3. Pathology

a. Application: Certain pathological conditions require either an increase in technique or a decrease in technique to satisfactorily demonstrate the anatomical area of interest.

b. Compensations: Pathological conditions are listed by those which require a decrease in technique and those which require an increase in technique, normally compensations are made in mAs.

Conditions which require 2 x mAs	Conditions which require 1/2 x mAs
Sclerosis	Destructive bone diseases
Fluid or Pus	Malnutrition
Contrast Media	Atrophy
	Malignant metastases
	Emphysematous tissue
	Arthritis

4. Problems

a. Given adult exposure of 70 kVp, 100 mA, 1/5 s, 40" FFD, what exposure would you use for the following:

(1) Child seven years old
kVp mAs

*(2) Infant 18 months old
kVp mAs

(3) Girl nine years old
kVp mAs

*(4) Boy three years old
kVp mAs

b. Given adult exposure of 65 kVp 200 mA, 3/4 s, 40" FFD, what exposure would you use for the following:

*(1) 60-year-old man
kVp mAs

(2) 83-year-old invalid, bedridden two years
___ kVp ______ mAs

(3) 40-year-old adult, bedridden seven months
____ kVp ____ mAs

*(4) Patient has fluid present
____ kVp ____ mAs

NOTE: All of the compensation factors in this section are for use with Optimum kVp Technique ONLY.

ANSWERS (FOR ALL UNSTARRED PROBLEMS)

Page 15, para 3:

a(2) 80 kVp, 50 mAs
b(2) 75 kVp, 45 mAs

Page 18, para 3

a(2) 70 kVp, 72 mAs
b(2) 70 kVp, 32 mAs
c(2) 90 kVp, 25 mAs
(4) 90 kVp, 36 mAs

Page 21, para 4

a(2) 60 kVp, 60 mAs
b(2) 51 kVp, 15 mAs
(4) 76 kVp, 5 mAs
c(2) 86 kVp, 7.5 mAs
(3) 104 kVp, 2.5 mAs
(4) 92 kVp, 1.25 mAs

Pages 22 & 24, para 3:

a(2) 80 kVp, 25 mAs
(4) 90 kVp, 2.5 mAs
b(1) 75 kVp, 53 mAs
(3) 80 kVp, 9 mAs
(5) 85 kVp, 25 mAs

Page 25, para 3:

a(4) 75 kVp, 15 mAs
(6) 70 kVp, 8 mAs
b(2) 75 kVp, 25 mAs
(3) 95 kVp, 5 mAs

Pages 28 & 29, para 4

a(1) 70 kVp, 10 mAs
(3) 70 kVp, 10 mAs
b(2) 65 kVp, 37.5 mAs
(3) 65 kVp, 75 mAs

756

RADIOGRAPHIC EXPOSURE TECHNIQUE

OBJECTIVES:

1. State the differences which exist between:
    a. the theories of Variable kVp and Optimum kVp techniques.
    b. typical Variable kVp and Optimum kVp chart formats.
2. List at least three advantages of Optimum kVp over Variable kVp techniques.
3. Determine the "proper" exposure to be used for a given body part when given a specific technique chart or "Supertech" slide rule.

A. Standardization & Control in Radiography

1. ____________________

2. ____________________

B. Radiographic Quality

757

C. Factors to be considered in formulating a technique

D. Methods for selecting technique factors

766

E. Comparison of Variable kVp to Optimum kVp techniques

F. Advantages of Optimum kVp

G. Setting up an Optimum kVp Chart

NOTE: PAGE 759 HAS BEEN DELETED; HOWEVER ALL MATERIAL HAS BEEN INCLUDED.

Optimum kVp Technic Chart 100 mA, 100 kVp Field Unit

This Optimum kVp Technique Chart is primarily for use with the full wave rectified 100 mA, 100 kVp, (stationary anode) field unit with the Army field table. Film holders on this chart are cassettes with high speed screens. The Bucky used is 6:1 where indicated by a "B" in the last column. An asterisk (*) indicates non-routine positions. A double asterisk indicates a position for which factor compensations for patients above the normal centimeter range will exceed tube limits. Use the blocked chart below to adjust for centimeter measurements above or below the centimeter range shown.

NOTE: This chart is valid for any radiographic unit when employing optimum kVp technique. Compensations for higher grid ratios should be made in kVp.

3-5 cm. below	1-2 cm. below	In range	1-2 cm. above	3-5 cm. above
1/2 x S	2/3 x S	basic S	basic S x 1 1/2	basic S x 2

PART	POSITION	FILM	CM	KV	FOCAL SPOT	MA	S	FFD	B	NB
HAND	PA	1/2 10C	2-4	50	Sm	25	.2	40		NB
	Oblique	1/2 10C	3-5	50	Sm	25	.2	40		NB
	Lateral*	1 8L	7-10	50	Sm	20	.6	40		NB
WRIST	PA	1/4 10C	3-5	50	Sm	25	.2	40		NB
	Oblique	1/4 10C	4-6	50	Sm	20	.3	40		NB
	Lateral	1/4 10C	5-8	50	Sm	20	.6	40		NB
	PA w/Ulnar flexion	1/4 10C	3-5	50	Sm	25	.2	40		NB
FOREARM	Dist, AP	1/2 10L	4-7	60	Sm	25	.2	40		NB
	Dist, Lateral	1/2 10L	6-9	60	Sm	25	.3	40		NB
	Prox, AP	1/2 10L	6-9	60	Sm	25	.3	40		NB
	Prox, Lateral	1/2 10L	7-10	60	Sm	25	.3	40		NB
ELBOW	AP	1/2 10C	6-9	60	Sm	25	.3	40		NB
	Lateral	1/2 10C	6-9	60	Sm	25	.3	40		NB
	Jones*	1 8L	8-11	60	Sm	25	.4	40		NB
HUMERUS	Dist, AP	1/2 10L	7-10	60	Sm	25	.3	40		NB
	Dist, Lateral	1/2 10L	7-10	60	Sm	25	.3	40		NB
	Full, AP, EX	1/2 14L	7-11	60	Sm	25	.3	40		NB
	Full, AP, IN	1/2 14L	7-11	60	Sm	25	.3	40		NB
	Trans Thoracic*	1 10L	35-40	80	Lg	100	1.5	40	B	

PART	POSITION	FILM	CM	KV	FOCAL SPOT	MA	S	FFD	B	NB
SHOULDER	AP, EX	1 10C	11-15	75	Sm	30	.3	40	B	
	AP, IN	1 10C	11-15	75	Sm	30	.3	40	B	
	Superoinferior*	1 8C	7-12	70	Sm	25	.1	40		
SCAPULA	AP	1 10L	13-17	75	Sm	30	.4	40	B	
	Lateral	1 10L	18-22	75	Sm	30	1.0	40	B	
CLAVICLE	PA, R-L	2 10C	11-15	75	Sm	30	.3	40	B	
FOOT	DP, Oblique	1 10L	6-9	60	Sm	30	.2	40		NB
OS CALCIS	Inferosuperior	1/2 10C	8-13	60	Sm	30	.3	40		NB
	Lateral	1/2 10C	5-8	60	Sm	30	.2	40		NB
ANKLE	AP	1/2 10C	8-11	60	Sm	25	.3	40		NB
	Oblique	1/2 10C	6-9	60	Sm	25	.2	40		NB
	Lateral	1 8L	6-9	60	Sm	25	.2	40		NB
LEG	Dist, AP	1/2 14L	8-11	65	Sm	25	.3	40		NB
	Dist, Lateral	1/2 14L	8-11	65	Sm	25	.3	40		NB
	Prox, AP	1/2 14L	10-13	65	Sm	30	.3	40		NB
	Prox, Lateral	1/2 14L	10-13	65	Sm	30	.3	40		NB
KNEE	AP, PA*	1 8L	10-13	65	Sm	30	.3	40		NB
	Lateral	1 8L	9-12	65	Sm	30	.3	40		NB
	Holmblad*	1 8L	12-16	75	Sm	25	.3	40		NB
	Beclere*	1 8C	12-16	75	Sm	25	.3	40		NB
	Settegast*	1 8L	10-13	65	Sm	30	.3	40		NB
			Measure as for AP							
FEMUR	Dist, AP & Lateral	2 14L	12-15	70	Sm	50	.4	40	B	
	Prox, AP & Lateral	2 14L	15-19	70	Sm	50	.6	40	B	
PELVIS	AP, Frogleg*	1 14C	17-21	65	Sm	50	1.25	40	B	
HIP	AP	1 10L	16-20	70	Sm	50	.8	40	B	
	Lateral	1 10C	22-26	85	Sm	50	.8	40	GC	
SACRUM	AP	1 10L	19-23	65	Sm	50	2	40	B	
	Lateral**	1 10L	29-33	80	Lg	100	2	40	B	
COCCYX	AP	1 8L	19-23	65	Sm	50	2	40	B	
	Lateral**	1 8L	29-35	80	Lg	100	2	40	B	
CERVICAL SPINE	AP	1 10L	10-12	60	Sm	50	.4	40	B	
	Open Mouth	1 8L	13-16	60	Sm	50	.8	40	B	
	Moving Jaw*	1 10L	10-12	55	Sm	10	3	40	B	
	Oblique*	1 10L	10-12	60	Sm	50	.4	40	B	
	Lateral	1 10L	10-12	70	Lg	100	.2	72		NB
	Flexion*	1 10L	10-12	70	Lg	100	.2	72		NB
	Extension*	1 10L	10-12	70	Lg	100	.2	72		NB

PART	POSITION	FILM	CM	KV	FOCAL SPOT	MA	S	FFD	B	NB
DORSAL SPINE	AP	1 14L	20-23	70	Sm	50	1.5	40	B	
	Lateral	1 14L	29-34	75	Lg	100	.8	40	B	
	Oblique*	1 14L	27-32	75	Lg	100	1.25	40	B	
LUMBAR SPINE	AP	1 14L	17-21	65	Sm	50	1.5	40	B	
	Lateral**	1 14L	25-30	80	Lg	100	1.5	40	B	
	Oblique*	1 14L	21-25	75	Lg	100	.8	40	B	
L-S ART	AP	1 10L	19-23	65	Sm	50	2	40	B	
	Lateral**	1 10L	29-34	80	Lg	100	2	40	B	
SACRO-ILIAC JOINTS	Oblique, R-L	2 10L	21-25	80	Lg	100	.8	40	B	
CHEST	PA	1 14L	21-24	80	Sm	50	.2	72		NB
	Lateral*	1 14L	29-34	90	Sm	50	.4	72		NB
	Oblique*	1 14L	25-29	85	Sm	30	.3	72		NB
	Lordotic*	1 14L	22-26	85	Sm	50	.2	72		NB
RIBS	Above, AP	1 14C	21-24	85	Sm	25	.4	40	B	
	Above, Obl 30°	1 14C	23-26	85	Sm	30	.4	40	B	
	Above, Obl 45°	1 14C	25-29	85	Sm	25	.6	40	B	
	Below, AP	1 14C	20-23	65	Lg	100	1	40	B	
	Below, Obl 30°	1 14C	22-26	65	Lg	100	1.25	40	B	
	Below, Obl 45°	1 14C	24-27	65	Lg	100	1.5	40	B	
ABDOMEN	AP	1 14L	17-21	65	Sm	50	1.5	40	B	
	Upright*	1 14L	20-24	65	Lg	100	1.25	40	B	
STERNUM	RAO	1 10L	22-25	70	Sm	25	3	40	B	
	Lateral	1 10L	29-34	85	Sm	50	1	40	B	
			Measure through entire thorax							
ACROMIO-CLAVICULAR JOINTS	AP W/WOW WTS	2 14C	12-16	80	Sm	50	.3	72		NB
		For broad patients use 4 8L								
SC JOINTS	PA, R-L	2 8L	20-22	75	Sm	30	1.5	40	B	
SKULL	PA, AP*	1 10L	17-21	80	Sm	30	1.25	40	B	
	Lateral, R-L	1 10C	13-17	80	Sm	30	.4	40	B	
	C-Towne	1 10L	17-24	80	Sm	50	1	40	B	
	B-Hirtz*	1 10L	21-25	80	Sm	50	1.25	40	B	
SINUSES	Caldwell	1 8L	17-21	80	Sm	50	.8	40	B	
	Waters	1 8L	19-23	80	Sm	50	1	40	B	
	Lateral	1 8L	11-15	80	Sm	50	.2	40	B	
	OM Sphenoid*	1 8L	19-23	80	Sm	50	1	40	B	

PART	POSITION	FILM	CM	KV	FOCAL SPCT	MA	S	FFD	B	NB
MANDIBLE	PA	1 8L	13-17	65	Sm	50	.6	40	B	
	Lateral	1 8C	10-14	70	Sm	25	.3	40		NB
			Measure through the angles of the mandible							
SCHULLER TMJ	Lateral, O-C, R-L	4 8L	13-17	65	Sm	50	1	40	B	
			Measure as for lateral skull							
MASTOIDS	Hickey's, R-L	2 8L	13-17	65	Sm	50	.6	40	B	
	Law's, R-L	2 8L	14-18	65	Sm	50	1.25	40	B	
NOSE	Lateral, R-L	1 8C	1-3	45	Sm	30	.1	40		NB
FACIAL BONES	Waters	1 10L	19-23	80	Sm	50	1	40	B	
	Lateral	1 8L	11-15	80	Sm	50	.2	40	B	
PETROUS RIDGES	Stenvers, R-L	2 8L	15-19	80	Sm	30	.8	40	B	
	Arcelins, R-L	2 8L	15-19	80	Sm	30	.8	40	B	
	Mayers, R-L	2 8L	20-24	80	Sm	50	1.25	40	B	
OPTIC FORAMEN	Rhese's, R-L	2 8L	17-21	80	Sm	30	1.25	40	B	
ZYGOMATIC ARCHES	B-Hirtz	1 10L	21-25	80	Sm	50	.6	40	B	

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* Additional views

** When compensating for patients above the centimeter range for these parts reduce the FFD to 30" and compensate from half the indicated time of exposure, otherwise the tube limits may be exceeded.

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RADIOGRAPHIC EXPOSURE TECHNIQUE

Optimum kVp is an approach to exposure technique in which the kVp is fixed (for a given part) at an optimum level and in which differences in part thickness are compensated for by regulating mAs.

Using the traditional Variable kVp approach to exposure of patients of varying part thickness, the kVp is changed. For thin parts less penetration thus lower kVp is needed; for thicker parts more penetration and thus higher kVp values are needed.

Using the Optimum kVp approach, the mAs is changed for varying part thickness. For thinner parts fewer X-rays are needed (lower mAs); for thicker parts more X-rays are needed (more mAs).

Both techniques produce good films, but Optimum kVp has more advantages. Compare the advantages listed in class to the following sets of exposure factors for the Lateral Skull.

LATERAL SKULL: average part thickness 13-17 cm

Variable	mid-range kVp	mAs	HU
	74	50	3700
Optimum	**kVp**	**mAs**	**HU**
	85	25	2125

(Both techniques are for use with the 50-100 mA Picker Field Unit.)

Charts are different on different types of machines. No single technique chart can be expected to be used on different types of machines. No single technique chart can be expected to produce films which will satisfy all radiologists. Technique charts then must not be considered as immutable. For varying situations, the technique chart must be changed.

772

765

WEEKLY OBJECTIVES AND GOALS
FIFTH WEEK - PHYSICS

By the end of the fifth week you will be tested on the following objectives. The examination will consist entirely of multiple choice items.

I. Film Processing (About 40% of the exam)

A. Procedures of Processing: Describe standard hand processing of x-ray films in terms of any of the following:

1. Order of use of chemical solutions.
2. Methods of film handling.
3. Duration of processing in each chemical solution.

B. Chemical Effects: Describe the effect on a film as a result of any one of the following changes from a normal hand processing procedure:

1. Develop but not fix.
2. Fix but not develop.
3. Insufficiently wash.

C. Describe the function of each of the following: developer, stop bath, fixer, rinse, wash.

II. Film: Construction, Holders, Handling (About 25% of exam)

A. Name the materials which constitute the film base or emulsion and their functions.

B. Describe the construction and characteristics of cardboard holders and cassettes to include intensifying screens.

C. Describe the proper procedures to be used in handling x-ray film or holders.

D. Describe the appearance of any of the following specific artifacts on the film: developer splash; fixer splash; static electricity; dirty or damaged screens; light fog; crinkle marks.

III. Review

Approximately 35% of the exam will consist of review questions covering the following material from previous weeks: Primary and Secondary Factors; Compensation Factors; Accessory Devices.

CONSTRUCTION AND HANDLING OF X-RAY FILM

OBJECTIVES:

1. Name the:
   a. material of which x-ray film base is made.
   b. materials of which x-ray film emulsion is made.
   c. light-sensitive material in x-ray film emulsion.

2. Describe the:
   a. function of gelatin in the emulsion of the film.
   b. function of silver bromide in the emulsion of the film.
   c. process of converting the latent image to a visible image.
   d. correct method of holding a film with one hand.
   e. effects of age and heat on a film.

3. Define: Latent Image

A. Construction of Film

1. History of Materials

2. Film base

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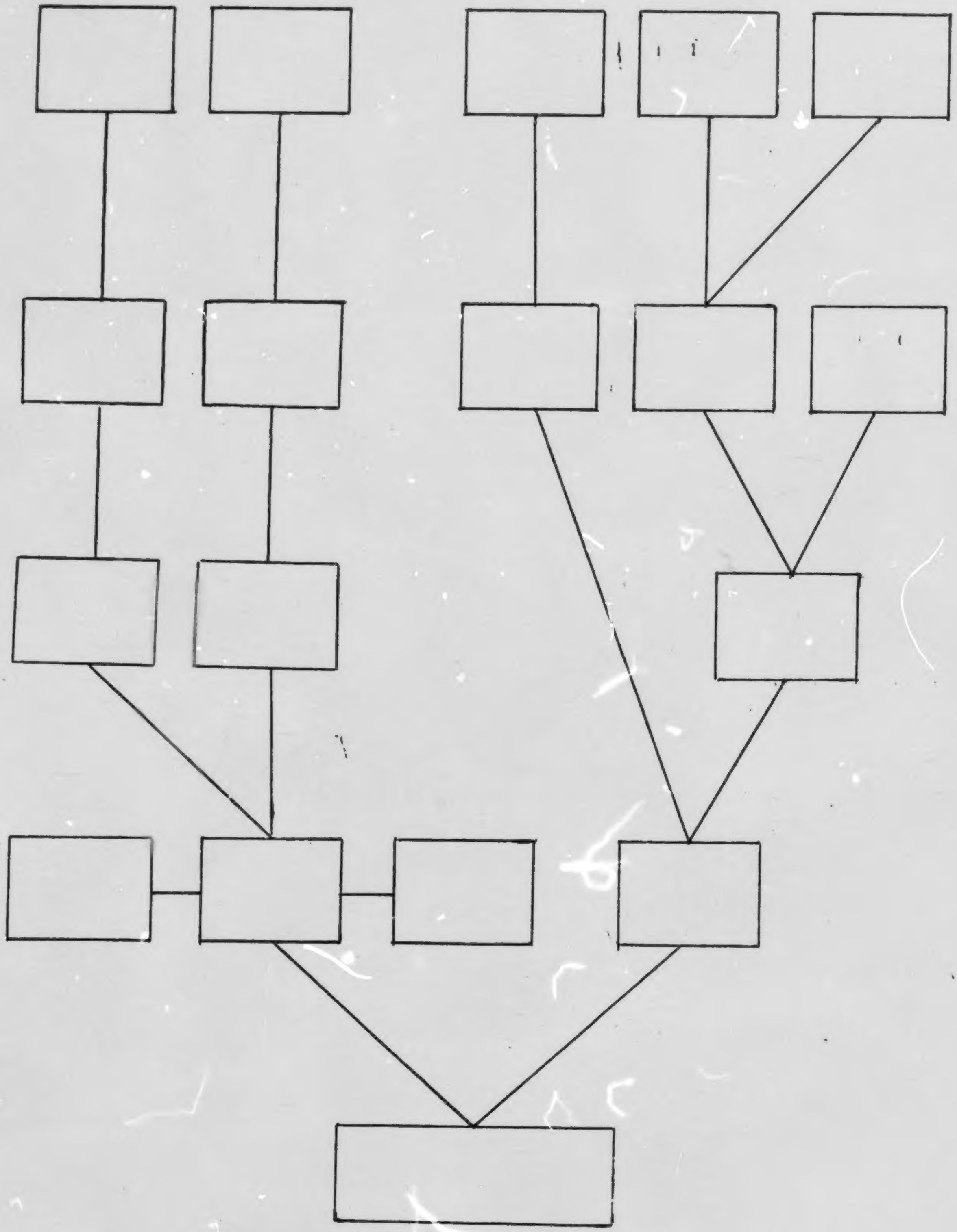

769

3. Emulsion

B. Characteristics of Film

1. Formation of latent image

2. Formation of visible image

a. development

b. fixing

C. Packaging

D. Fog

E. Storage, Use and Handling

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CONSTRUCTION AND HANDLING OF X-RAY FILM

Silver bromide crystals are mixed with an appropriate gelatin to form the x-ray film emulsion. When examined under the microscope, The emulsion is seen to be made up of countless tiny crystals of silver bromide embedded in the gelatin. Upon exposure and development, these crystals are changed into irregular clumps and strands of black metallic silver, which in the aggregate compose the roentgenographic image.

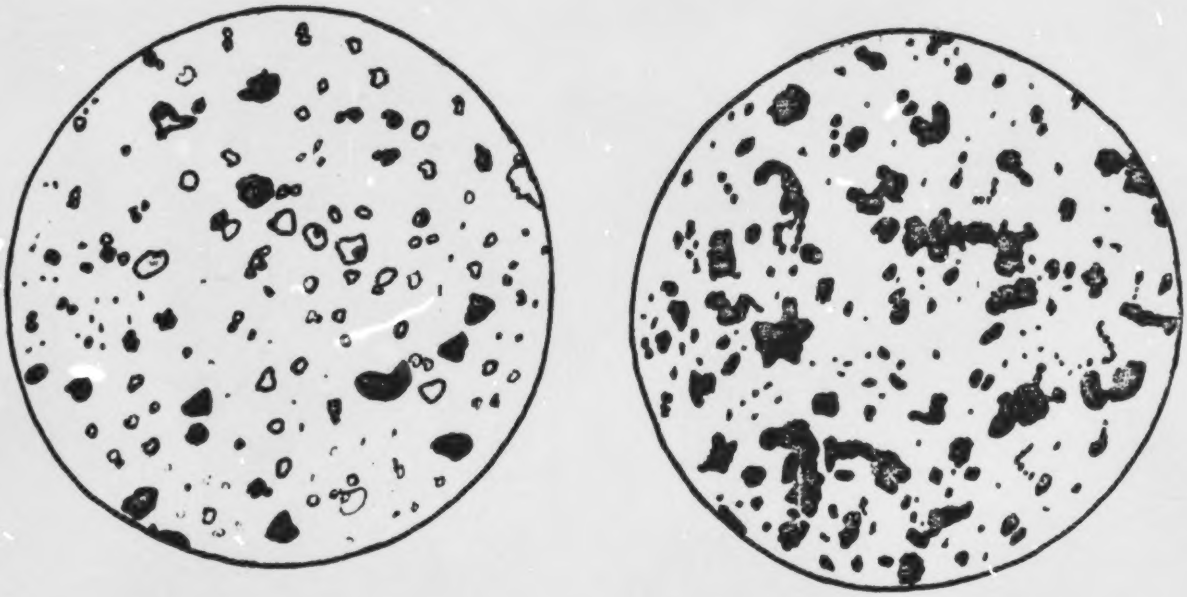
Sensitization of the emulsion is a complicated chemical process that assures the presence of submicroscopic quantities of silversulfide or photosensitive colloidal silver "specks" chiefly on the surfaces of the majority of the crystals. They provide the future sites for the beginning of the development phenomenon leading to the production of the visible image. Upon exposure the specks incite the crystals to pass through the ionic phase of activity that upon chemical development leads to neutrality. This leaves black metallic silver on the base support and the byproducts of the reaction go into the developer and fixer solutions. This is a basic response of any photographic emulsion whether it is exposed to light or to x-rays.

Each emulsion layer is about two ten-thousandths of an inch thick. Since x-rays pass readily through x-ray film, and also through x-ray intensifying screens, an emulsion is coated on both sides of the film base providing a greater effect upon exposure to x-rays than would be possible with an emulsion coated on only one side.

There are two types of x-ray film used in medical roentgenography: screen type film and direct exposure film. Screen type film is particularly sensitive to the fluorescent light of x-ray intensifying screens. The visible light of the screens amplifies the direct action of the x-rays. Although it is not too sensitive to the action of the direct exposure of x-rays, it may be used in roentgenography of the smaller thicknesses of the body such as the hand and foot.

Direct exposure film is especially sensitive to the direct action of the x-rays and is used only for thin parts of the body. Its silver content is greater and has a higher inherent contrast than the screen type film. This film should never be used with x-ray intensifying screens for it is not as sensitive to fluorescent light. When used with intensifying screens, screen type film is much faster than the direct exposure type. When screen type film is used without the intensifying screens, however, it is slower than the direct exposure type when exposed to the direct action of the x-rays alone.

Photography of the x-ray image on a fluorescent screen (photofluorography) requires the use of either of two types of single coated photographic film. One type is most sensitive to the blue fluorescence of one kind of fluorescent screen; the other is most sensitive to the green fluorescence of another type of screen. These films are usually supplied in rolls or sheets.



Photomicrograph (2500X) of silver bromide emulsion. Left--before exposure and development. Right--after exposure and development.

775

FILM HOLDERS AND HANGERS

OBJECTIVES:

1. Identify the parts of a cardboard holder or cassette when given a cross-sectional diagram of the holder.

2. Name the fluorescing crystals on intensifying screens.

3. Describe:

    a. the construction of an intensifying screen.
    b. proper film handling techniques in loading and unloading cardboard holders and cassettes.

4. Match intensifying crystal size with each of the following factors:

    a. speed of screens.
    b. detail produced on the film.
    c. contrast produced on the film.

A. Purpose of a Film Holder

B. Sizes of Film Holders

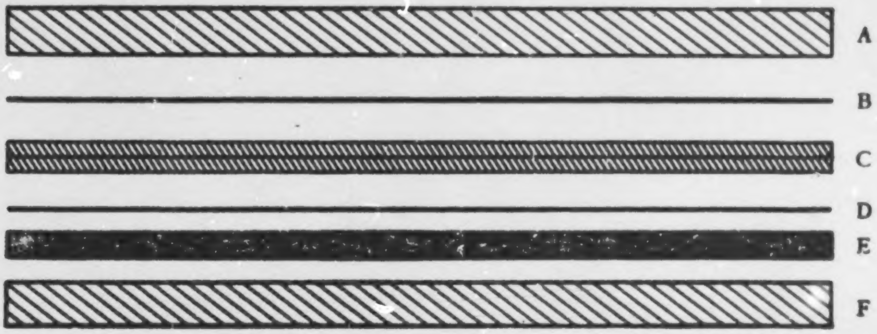
779

C. Types of Film Holders

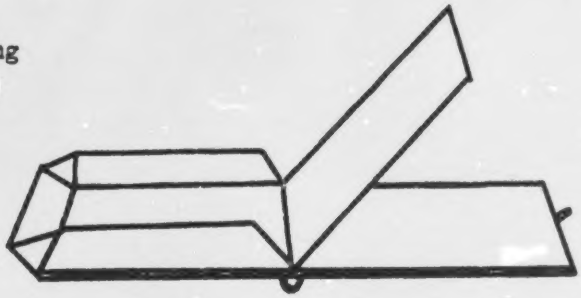
1. ______________________

a. Theory of Exposure

b. Construction



c. Procedure for Loading

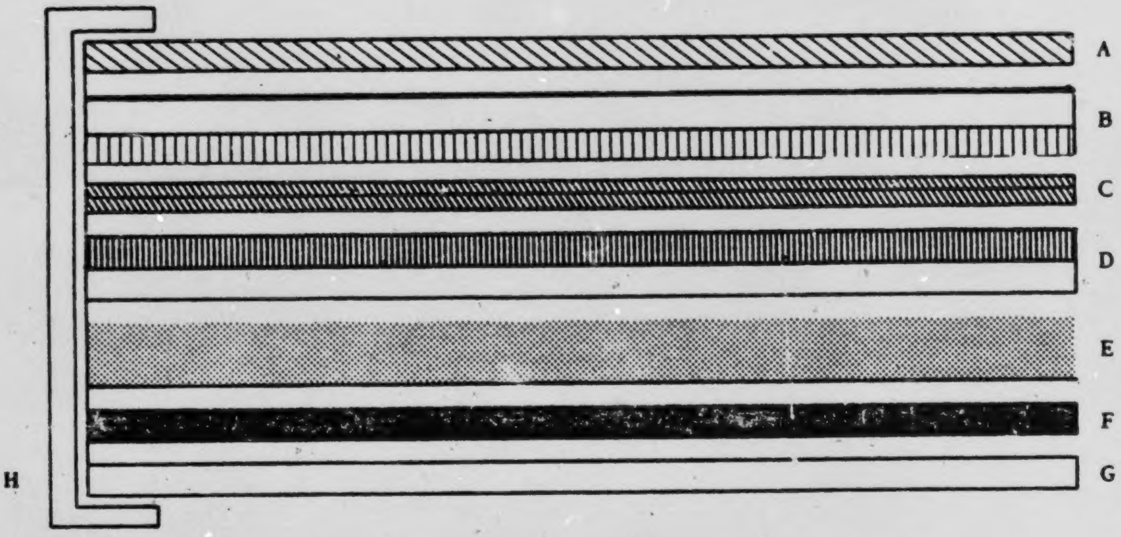


d. Advantages versus Disadvantages

2. ______________________________

a. Theory of Exposure

b. Construction



c. Advantages versus Disadvantages

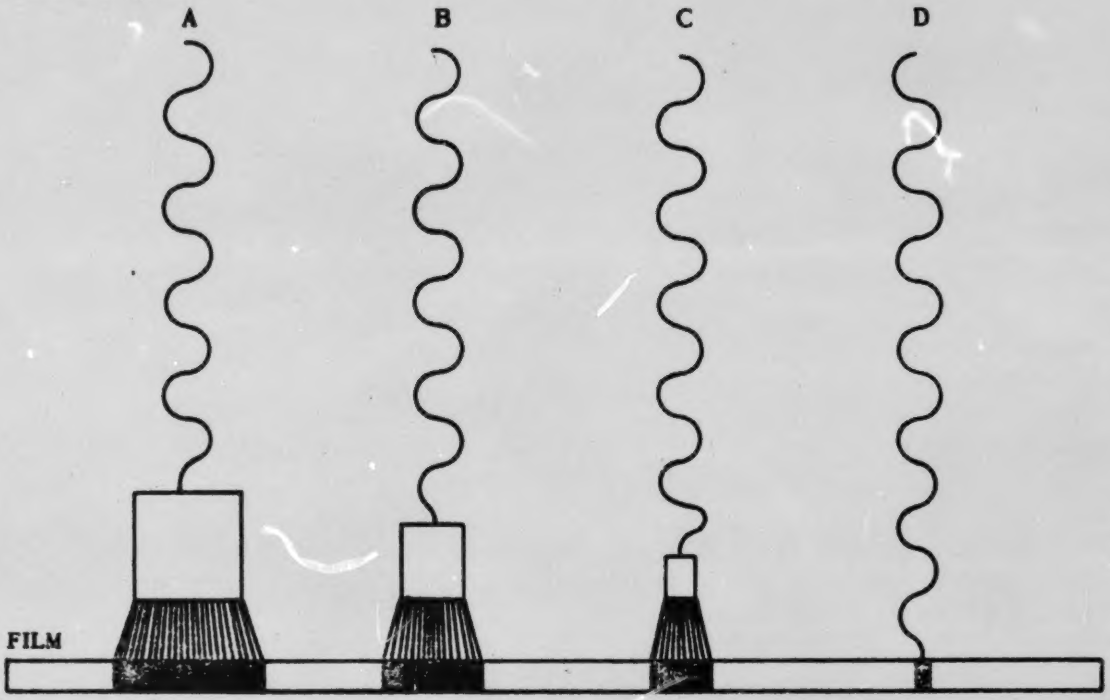
D. Intensifying Screens

1. Construction

2. Crystal size

Crystal Size	Speed	Detail	Contrast
Large			
Medium			
Small			
Direct Exposure			

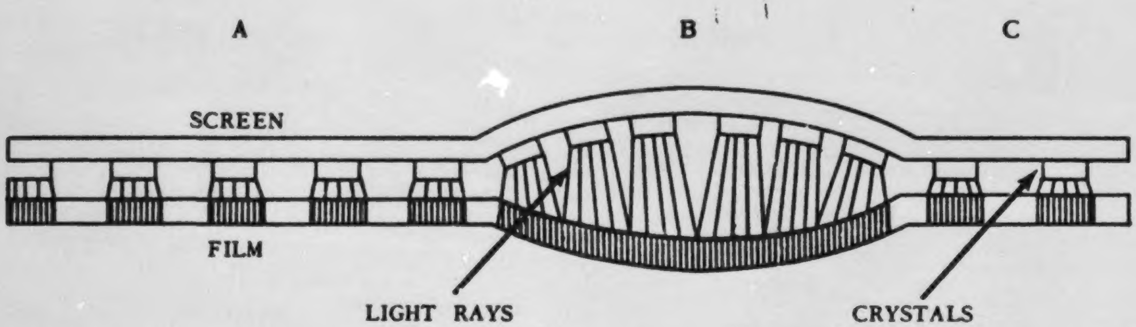
779



Effect of crystal size on speed of intensifying screen and on detail of roentgenographic image. A, large crystal size—more light is produced by the crystal and a high-speed screen results. B, medium sized crystals—a medium amount of light is emitted, and a medium or par-speed screen results. C, small crystals—less light is emitted, and a slow-speed but high-definition screen results. D, direct action of X-rays—no crystals are used, and only X-rays expose the film. There is a drastic reduction in speed, but definition is greatly improved.

3. Film Screen Contact Test

783



Poor screen contact produces a blurred roentgenographic image. In areas A and C, the film and screen are in good contact—good detail results. In area B light rays from one crystal cross those of others, and the resultant image of each crystal blurs into those of the adjacent crystals.

E. Removal and Replacement of Old Screens

1. Reusable Screens

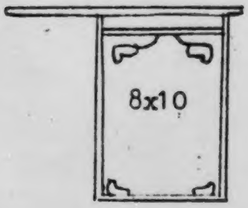
2. Replacement of Screens

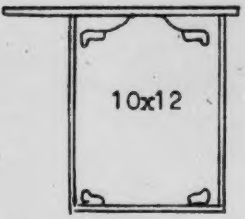
F. Cleaning Screens

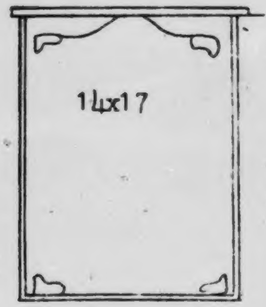
1. Dry Cleaning

2. Wet Cleaning

G. Film Hanger







DARKROOM CONSTRUCTION

OBJECTIVES:

1. State the:
   a. advantages and/or disadvantages of each of the three types of darkroom entrances.
   b. two types of darkroom lighting and conditions of use for each.

2. List the items of equipment located in the manual processing darkroom on the:
   a. dryside.
   b. wetside.

A. Entrances

1. Criteria

2. Types

	Single Door	Double Door	Maze (Labyrinth)
Space			
Light			
Ventillation			
Traffic			

783

B. Lighting

1. White Lights

2. Safelights

C. Layout of Manual Processing Darkroom

1. Dry Side

2. Wet Side

787

3. Sketch

D. Layout of Automatic Processing Darkroom - Sketch

785

DARKROOM CONSTRUCTION

The processing room should be adjacent to the exposure room and should have a source of electricity for operating its apparatus. Lightproofing can be effected by the use of blankets, tarpaulins, canvas, or other light-opaque materials. A proper processing room is divided into a dry side and a wet side. The minimum distance between these areas is 4 feet.

The lighting in a darkroom is extremely important. Film exposed with x-ray intensifying screens is approximately 8 times more sensitive to safelight illumination than unexposed film. Because films are subjected to safelight illumination at the loading bench for a longer period than in any other zone, direct type safelight lamps over this area are liable to raise the amount of post-exposure fog to an undesirable degree. For this reason the loading bench should be illuminated by an indirect safelight lamp.

If the quality of the light from the safelight lamp is "safe", the illumination reflected from any other surface is also "safe" regardless of its color. The finish should reflect the maximum amount of safelight illumination and the color should be attractive and pleasant. In order to appear bright, the walls must reflect rather than absorb light from the safelight lamp. If the wall color is either within the same spectral range of yellow or yellow-red or a light-enough shade of any other color, it will reflect. It is also desirable to have a color that is pleasing under white light as well as safelight illumination. In permanent installations the ceiling and the upper 18 inches of the walls should be painted white to provide maximum reflection.

A simple method for checking safelight illumination is to cover part of a film and expose sections of the remainder for different lengths of time in the places where films will be uncovered in handling. This test film is then given standard development. If no fog shows on the parts that receive a reasonably long exposure, as compared with the covered part, the lighting may be assumed to be safe. If fog appears, the distance of the safelights from the film should be increased. All safelight lamps should be tested periodically for white light leaks, fading filters, and excess wattage of bulbs.

When not properly controlled, temperature and humidity have adverse physiologic effects on the worker as well as physical effects on film during handling and storage. The average zone of comfort lies within a humidity range of 40 to 60 percent and a temperature range of 67 to 83 degrees F. with air movement between 15 and 25 feet per minute (ordinarily considered "still" air.) An air velocity above 50 feet per minute is objectionable at temperatures below 80 degrees F., but is tolerable at higher temperatures. The air in the processing room should be maintained at a positive pressure (the air should be pumped in rather than out.) This will prevent dust from entering through the windows and doors. The incoming air from a permanent ventilating system should pass through filters to remove dust and should be sufficient in volume to change the air in the darkroom 6 to 10 times per hour.

The actual processing includes developing, rinsing, fixing, washing, and usually drying of x-ray films and should be done in an area separate from the loading bench. This arrangement avoids splashing of solutions on screens, films, and loading areas and prevents interference with loading bench operations.

There are two general types of tanks used for x-ray film processing. The master tank serves as a water jacket to hold insert tanks and usually provides space between the insert tanks for rinsing and washing of films. If a washing tank is available, washing of the films is accomplished in that tank. The insert tanks are removable containers for individual processing solutions and are placed in the water jacket of the master tank. Insert tanks are made of stainless steel and are constructed in either a 5 gallon or a 20 gallon size. Often the tank capacity is only approximate so it is necessary to compute the actual volume by using the following formula:

$$\text{Capacity of tank in gallons} = \frac{\text{Width} \times \text{Length} \times \text{Depth (minus 1 inch)}}{231}$$

When a single compartment wash tank is used, an overflow pipe is provided. The water flows from the inlet pipe between and along the surfaces of the films then into the overflow pipe. This arrangement permits rapid washing because of the speed and thoroughness with which fresh water is circulated across the films.

The temperature of the solutions should be controlled within a close range. The ideal situation would be to maintain both the air and the tap water at a temperature of 68° F. However, the water source is seldom at this temperature for any length of time. To maintain an optimum temperature for processing either hot or refrigerated water must be added. Since both may be scarce, some measures of temperature control should be used that utilizes the minimum of tempered water.

A detachable refrigeration unit is normally supplied for use with the processing tanks to temper the processing solutions. In the field the temperature of the solutions often drops below safe processing values. A suitable immersion heating unit can readily raise the temperature of the solution to the required value. The minimum temperature should be 60° F.

DARKROOM PROCESSING

OBJECTIVES:

1. State (when using the hand processing system) the:
   - a. functions of developer, rinse, fixer, wash in film processing.
   - b. factors which affect film development time.
   - c. duration of processing in each chemical solution.
   - d. effect on a film of any of the following incorrect procedures:
     - 1) develop but not fix.
     - 2) fix but not develop.
     - 3) insufficiently wash.
2. Describe (when using the hand processing system) the:
   - a. order of use of chemical solutions.
   - b. methods of film handling.

A. Processing of Latent Image

1. Developer

a. Function

b. Constituents

NOTE: PAGE 789 HAS BEEN DELETED; HOWEVER ALL MATERIAL HAS BEEN INCLUDED.

2. Fixer (Hypo)

a. Function

b. Constituents

B. Factors Affecting Development Time

791

C. Systems of Processing

1. Development-Replenisher

a. Theory

b. Characteristics

c. Rate of ____________________

d. Discarding Solutions

794

2. Systems of Rinse
   - a. Time
   - b. Types of Rinses

3. Fixing--Replenishment System
   - a. Theory
   - b. Characteristics

c. Rate for 5 Gallons Fixer

	Time	Films	Procedure	
(1)	5 min.	0-50	Remove 2 qts.	Add 2 qts. Replenisher
(2)	5 min.	51-100	" " "	" " " "
(3)	5 min.	101-150	" " "	" " " "
(4)	6 min.	151-200	" " "	" " " "
(5)	7 min.	201-225	" " "	" " " "
(6)	8 min.	226-250	" " "	" " " "

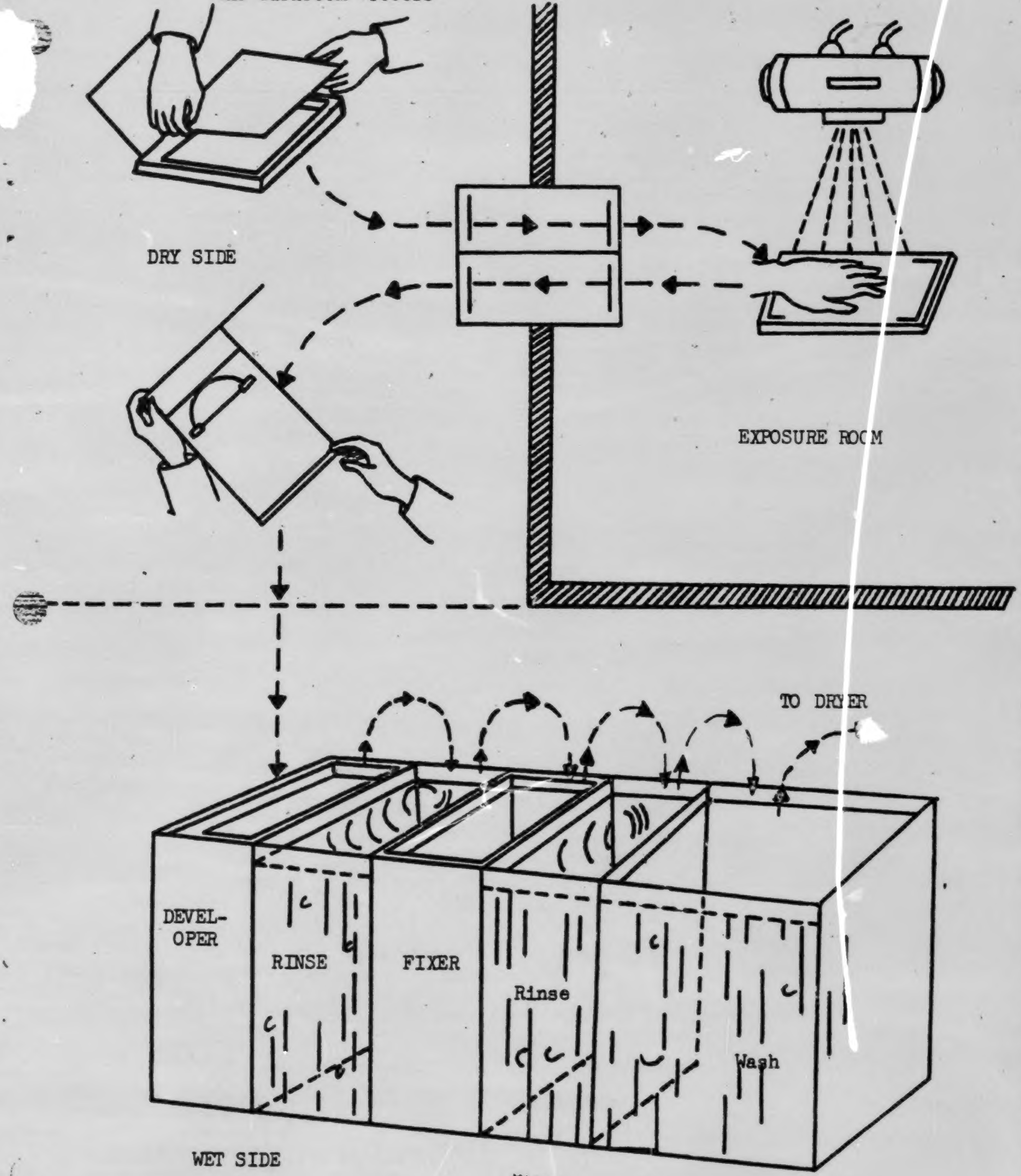
(7) Discard after 250 films or 3 months.

F. Optional Rinse

G. Wash System

H. Drying System

The Darkroom Process


DRY SIDE
EXPOSURE ROOM
TO DRYER
DEVEL-
OPER
RINSE
FIXER
Rinse
Wash
WET SIDE

DARKROOM PROCESSING

Uniform roentgenographic quality can only be achieved through control and standardization of processing procedures. X-ray film is manufactured to produce a consistently uniform degree of density and contrast when correctly exposed and processed according to standard and accepted procedures. Familiarity with the performance of a particular film is necessary for any measure of standardized processing. Since the characteristics of density and contrast provided by a particular film and its developer are inherent, they may be considered constant. The sequence of chemical activities in standardized processing is smooth and organized, and produces a desired roentgenographic image only when standardized procedures are followed.

There are several ways in which a film may be developed but the standard time-temperature method is almost universally used. This method is virtually foolproof and provides an excellent means for checking x-ray exposures. The manufacturer formulates an x-ray developer to give the most desirable roentgenographic quality upon full development of the x-ray film within a limited temperature range. Variations from the optimum in temperature or developing time must be carefully compensated to maintain proper quality. Once standardization of processing rules are established and followed, overall changes in density and contrast can be attributed to exposure factors. Standardized processing of the film then can become a constant as long as a reasonable measure of discipline is exercised in the processing room. Photographic research has so standardized processing that operations in connection therewith have virtually been reduced to noting the solution temperature and setting an interval timer according to a simple time-temperature chart. This procedure, however, is based upon the accumulated knowledge of the many chemical and physical complexities relating to the exposure and the development response of the film. Despite the simplicity of a standard processing procedure it will not work satisfactorily if solutions are improperly mixed , contain poor quality chemicals, or are not used in accordance with the maker's instructions.

ARTIFACTS

OBJECTIVES:

Given a specific artifact (developer splash, fixer splash, static electricity, dirty or damaged screens, light fog, crinkle marks, foreign object) state:

1. at what point in handling it was produced.
2. how it would appear on the film in terms of:
   - a. characteristic shape or appearance.
   - b. dark vs light.
3. which technologist was responsible for producing it.
4. how it was produced.
5. how it could have been avoided.

A. Definition

B. Exposure Room Artifacts

797

C. **Darkroom Artifacts**

1. **Dry Side**

2. **Wet Side**

800

TABLE OF CONTENTS

EIGHTH WEEK - PART IV ONLY

SUBJECT PAGE

Weekly Objectives 1

Electricity, Ohm's Law 2

Magnetism and Electromagnetism 8

Transformers and Autotransformers 17

Meters 22

Timers 27

Rectification 29

X-Ray Machine Circuits 33

Electrical Protection 39

WEEKLY OBJECTIVES AND GOALS
EIGHTH WEEK - PHYSICS

By the end of the eighth week you will be tested on the following objectives. The examination will consist entirely of multiple choice items.

I. Electricity and Magnetism (About 25% of the exam)

A. Describe the relationships which exist between voltage, current and resistance.

B. Describe the theory of operation and/or function (as used in an x-ray machine) of any of the following electromagnetic devices: Step-up and step-down transformers, autotransformer, choke coil, meter.

II. Spin Top Timer-Rectification Tests (About 15% of the exam)

Perform mathematical computations (from memorized relationships) using the Spin Top Timer-Rectification test in any of the following ways:

A. Given an exposure time determine how many dots should be produced when using either full-wave or half-wave rectification in either the United States or overseas (four possible situations).

B. Given a number of dots produced, with a given mA value, with a specified mode of rectification in a given geographical location, determine:

1. The exposure time used.
2. What mAs was produced.
3. Whether the timer was faulty and if so, whether it runs fast or slow.
4. Whether the rectification system is malfunctioning.
5. Whether a combination of 3 and 4 above exists.

III. Electrical Symbols and Machine Circuits (About 35% of the exam)

Given a schematic diagram of a basic X-ray machine circuit or element within that circuit (refer to page 205) for reference:

A. Locate any specific element in the diagram when given its name or function.

B. Identify any indicated element in the diagram.

C. Specify the electrical function of any indicated element in the diagram.

IV. Review

Approximately 25% of the exam will consist of review questions covering the following material from previous weeks: Compensation Factors, Primary and Secondary Factors, Optimum kVp, Radiation Protection.

ELECTRICITY, OHMS LAW (AC AND DC)

OBJECTIVES

1. List the three basic electrical factors.
2. Define: AC cycle, frequency, impulse.
3. Diagram: simple series and parallel circuits.
4. State:
    a. Ohm's Law.
    b. the type of current represented in a given diagram.
    c. how electrical paths, voltages, currents and total resistance compare in series and parallel circuits.
5. Convert (when given the frequency):
    a. AC impulses to seconds of exposure.
    b. seconds of exposure to AC impulses.

A. Electricity

1. Definition

2. Three Basic Electrical Factors (review)

NOTE: PAGE [illegible] HAS BEEN DELETED [illegible]. ALL MATERIAL HAS BEEN INCLUDED.

B. Ohms Law

1. Statement of Law:

2. Symbols

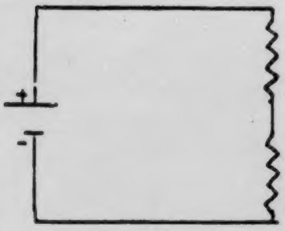
3. Formulas

C. Circuits

1. Definition

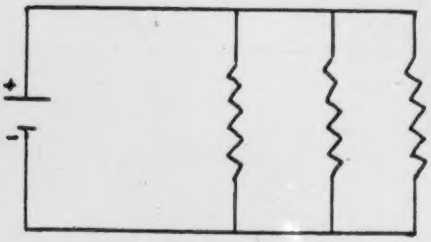
2. Types

   a. ________________



804

b. ____________________



D. Types of Dynamic Electricity and Waveforms

1. ______________ Current

a. Definition

b. Types

(1) ___________________________

(a) Definition

(b) Waveform

(2) ___________________________

(a) Definition

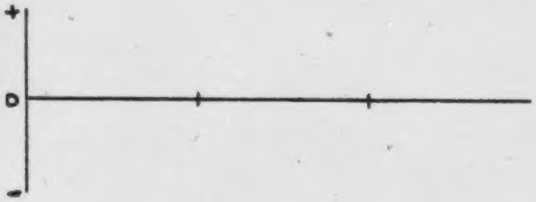
(b) Waveform

804

2. ________________ Current

a. Definition

b. Waveform



c. Terminology

E. Impulse-Time Relationship

806

QUESTIONS AND PROBLEMS

1. What is the frequency of United States current?

2. What is the frequency of AC normally used outside the U.S. ?

3. How many impulses are produced per second in the U.S. ?

4. How many impulses are produced per second in countries using 50 cycle current ?

5. 3/10 second = ______ impulses (60 cycle/s)

6. 20 impulses = ______ seconds (60 cycle/s)

7. An exposure of the abdomen uses 70 kVp, 100 mA, 80 mAs, 40" FFD. How many impulses would this exposure produce ?

8. A 9-volt battery will deliver ________ amperes of current through a resistance of 4½ ohms.

9. A 12-volt automobile battery sends 2 amperes of current through a __________ ohm resistance.

10. To get 5 amperes of current flowing through a 20-ohm resistance a _________ volt battery is required.

11. 50 mA = ________ amperes.

12. $\frac{150}{1{,}000}$ amperes = ___________mA.

13. 70 kVp = __________ volts.

14. 55,000 volts = ______kVp.

15. The technique for a C-Spine series calls for 70 kVp, 100 mA, ¼ s, 40" FFD. What resistance will be present within the x-ray tube with these factors applied to it ?

806

MAGNETISM AND ELECTROMAGNETISM

OBJECTIVES:

1. Name one electromagnetic device which operates using:
   a. relative motion.
   b. mutual induction.
   c. self induction.
2. Define: Electromagnetism, Electromagnetic Induction.
3. State the:
   a. fundamental law of magnetism.
   b. electromagnetic principle involved and its function for each of the following devices:
      1) generator.
      2) choke coil.
      3) relay (contactor).
      4) transformer.
      5) autotransformer.

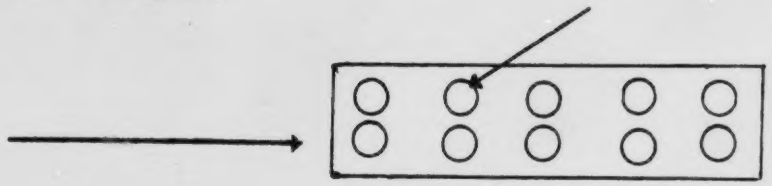
A. Magnetism

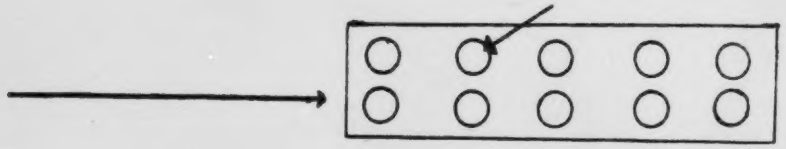
1. Definition

2. History

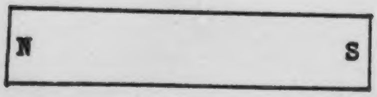
3. Magnetic Theory

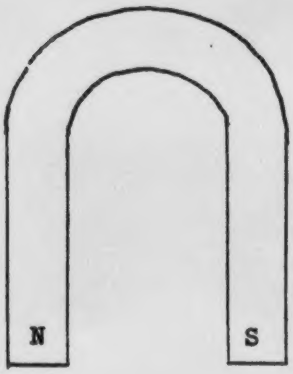
a. Atomic Alignment

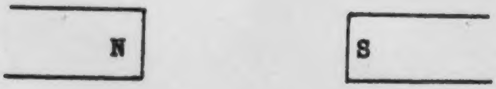




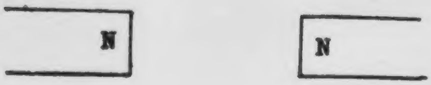
b. **Fields (flux lines)**







ATTRACTION



REPULSION

808

4. **Types of Magnetism**

5. **Characteristics**

6. **Laws of Magnetism**

810

809

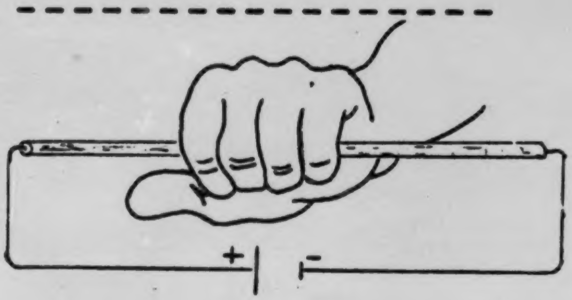
B. **Electromagnetism**

1. **Definition**

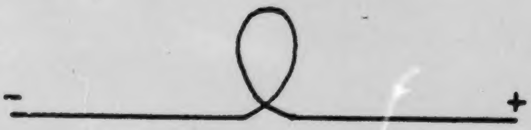
2. **Theory**

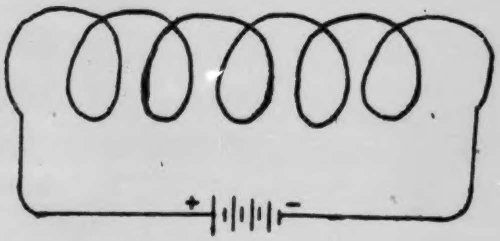
a. ---------------------

b. ---------------------



3. **Current in a Helix (coil)**





811

810

C. Electromagnetic Induction

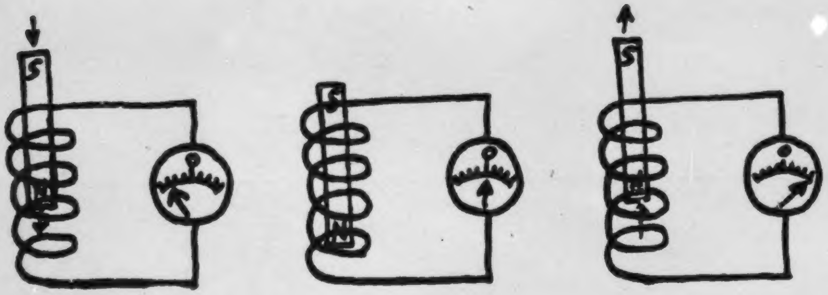
1. Definition

2. Principle

3. Types

a. ________________ ________________

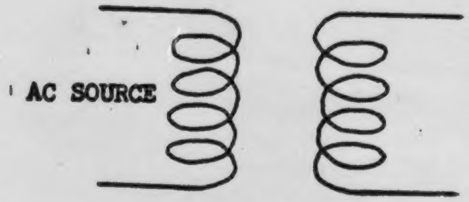
Used in ________________



812

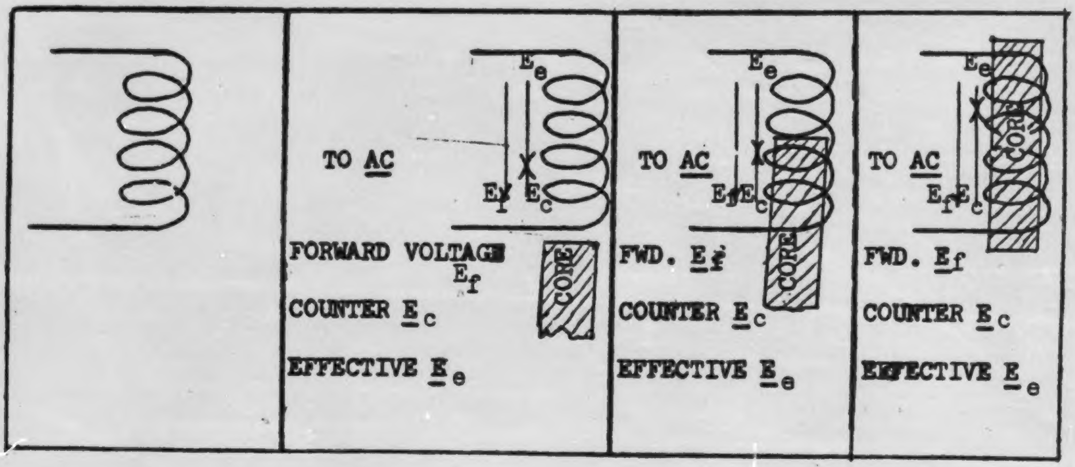
b. ______________ ____________

Used in ________________



c. __________ ______________

Used in ________________ and ________________


E_e
TO AC
E_f E_c
FORWARD VOLTAGE E_f
COUNTER E_c
EFFECTIVE E_e
CORE
E_e
TO AC
E_f E_c
CORE
FWD. E_f
COUNTER E_c
EFFECTIVE E_e
E_e
TO AC
E_f E_c
CORE
FWD. E_f
COUNTER E_c
EFFECTIVE E_e

MAGNETISM AND ELECTROMAGNETISM

Magnetic materials consist of millions of tiny elementary magnets (magnetic dipoles) which are so small that they cannot be seen by an optical microscope (probably molecular or atomic in size). When their north poles face one end of the body while their south poles face the other end, the body acts as a magnet. In an unmagnetized body, these tiny dipoles are arranged haphazardly with no definite order. If an unmagnetized iron bar is stroked with a strong magnet, its magnetic dipoles align themselves in one given direction and the bar becomes magnetized.

Lines of force are assumed to leave the north pole of a magnet and enter the south pole of a magnet. They attract each other when they can join together in the same magnetic path; they repel each other when they try to travel in opposite directions.

Magnetic and electrical phenomena are closely related--electricity always produces magnetism; magnetism caused by an electrical current flowing through a conductor is called electromagnetism. In 1820, the Danish scientist Oersted observed that a compass or suspended bar magnetic was deflected when placed near a wire carrying an electric current, returning it to its original position when the current ceased.

The direction of the magnetic field about a current-carrying conductor can be determined by the left hand rule--grasp the conductor in the left hand with the thumb pointing in the direction of electron flow. The fingers will then point in the direction of the magnetic lines of force.

A magnetic field exists about a wire only during the time the current is flowing; when the current ceases to flow, all the magnetism about the wire collapses back into the wire.

The strength or intensity of the magnetic field around a current-carrying conductor increases or decreases when the current increases or decreases. Reversing the direction of current in the conductor reverses the direction of the magnetic field.

If the conductor through which the current is flowing is bent in the form of a loop, the same circular lines of force, or magnetic field, surround the conductor as when it is straight; all the lines of force enter one side (face) of the loop and leave on the other side, resulting in a north pole on one face and a south pole on the other. If several loops or turns of wire are so wound as to form a coil, it is a helix or a solenoid. During current flow, the intensity of the magnetic lines of force around such a coiled wire is proportionately greater than those around a single loop of wire.

If a piece of magnetic material--usually soft iron--is placed within a solenoid through which current is flowing, the magnetic properties of the solenoid are tremendously increased. The inside of any coil is termed the core, and if the coil is wound on a core of magnetic material, it is called an electromagnet.

Electromagnets are widely used in electrical equipment, and the principles of electromagnetism are utilized in many of the devices in an x-ray machine circuit, such as relays, remote control switches, circuit breakers, and many other devices.

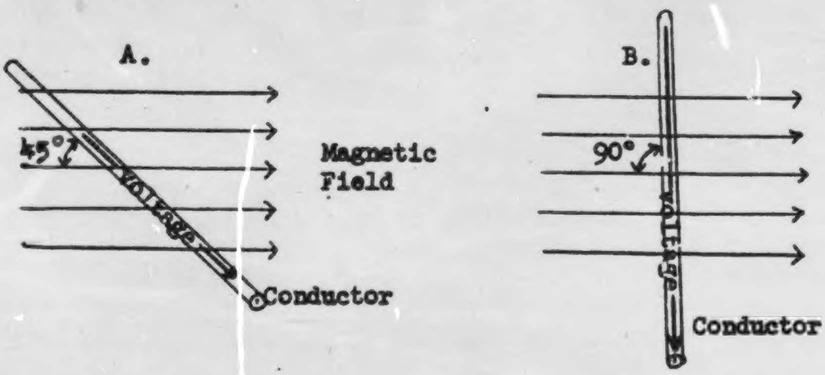
The method whereby moving magnetic fields produces electric current is electromagnetic induction. Whenever a conductor forming part of a closed circuit cuts across magnetic lines of force, an electric current is induced in the conductor. In 1831, Faraday demonstrated this principle by rapidly moving a wire through a magnetic field causing an electric current to flow in the wire. If the conductor does not form part of a closed circuit, no current flows but a voltage (e.m.f.) is induced in the wire.

The magnitude of the induced voltage is dependent upon four factors: (1) the speed or rate at which the wire moves--the faster the wire moves, the more lines of force it will cut; (2) the strength of the magnetic field--when the lines of force are closely concentrated, the conductor cuts more lines per second; (3) the angle between the motion of the conductor and the direction of the magnetic lines of force--as the angle approaches 90 degrees, the voltage increases in magnitude because more lines of force are being cut per second; (4) the number of turns in the conductor--each turn of the wire cuts the lines of force--a 100-turn coil cuts the lines of force 100 times as often as a single wire moving at the same speed in the same magnetic field.

When the current flowing through a conductor is not uniform, there will be corresponding changes in the magnetic field. If a second (secondary) coil is placed near the first (primary) coil with its changing magnetic field, an alternating e.m.f. will be induced in the second coil. For mutual induction (inductance between two coils acting together) to occur, the magnetic field must change in strength or direction.

Self-induction (the inductance of a single coil) is the action producing a counter (back) e.m.f. in a conductor or circuit whereby the self-induced voltage opposes the flow of current. In a circuit consisting of a switch in series with a coil of wire in which a uniform DC is flowing, the instant the switch is closed a magnetic field builds up which cuts through the coil producing a voltage (counter e.m.f.) which will always be in the opposite direction of the voltage causing the original current to flow. The field surrounds the conductor in concentric circles, increasing in intensity to a maximum where it remains as long as current flows. The moment the switch is opened the current stops, the field collapses, and the lines of force move across the coil in the opposite direction from that occurring when the switch is closed. This causes a short-lived induced voltage which tends to keep the current flowing in its original direction. Thus when the switch is closed, there is a short-lived voltage which tends to oppose the flow of current; when the switch is opened, the self-induced voltage is reversed and tends to keep the current flowing in its original direction for a short time. In a uniform DC the self-induced voltage is present only when the current is started or stopped. When an AC is used, the electrons are starting and stopping constantly and, as a result, the self-induced voltage is constantly opposing the current that causes it.

The addition of a soft iron core inside the coil concentrates the magnetic field, thereby increasing the magnitude of the self-induced voltage that opposes the original current. The magnitude of the induced voltage also depends on how far the iron core is pushed into the coil. The choke coil is designed on this principle. The current delivered through a choke coil may be varied by changing the placement of the iron core.



When a conductor cuts magnetic lines of force, a voltage is induced into the conductor. The magnitude of this voltage depends on the number of lines of force cut per second. If a wire cuts perpendicular (90°) to the lines of force (as in B), the induced voltage will be greater than when it cuts at (45°), as shown in A.

TRANSFORMERS AND AUTOTRANSFORMERS

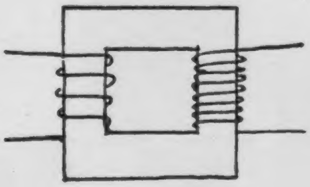
OBJECTIVES:

1. List:
   a. the two types of transformers.
   b. the components which comprise the transformer and autotransformer.
2. State:
   a. the principles of electromagnetic induction used in the transformer and autotransformer.
   b. the functions of the step-up transformer and autotransformer.
3. Define: Transformer.
4. Describe:
   a. the operation of the transformer.
   b. the difference in construction of the step-up and step-down transformer.
5. Calculate the primary (or secondary) voltage and current when given the transformer ratio and the secondary (or primary) voltage and current.

A. Transformers

1. Definition

2. Construction



3. Operation

4. **Efficiency**

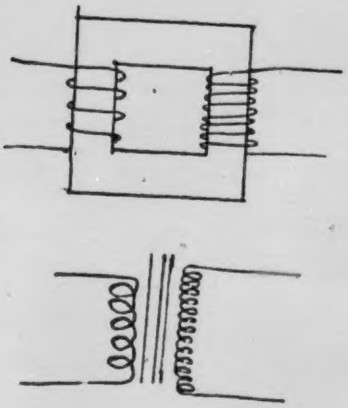
   a.

   b. **Losses**

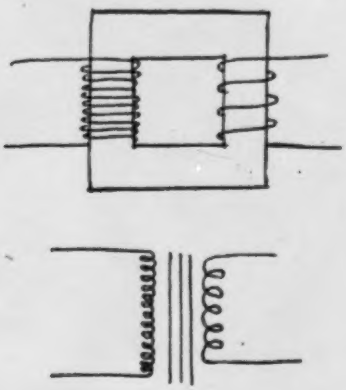
5. **Power Relationship**

6. **Types**

   a. ________ ___



b. ______ ______



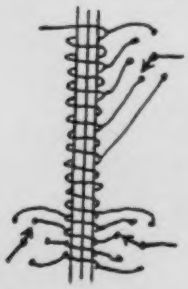
7. Formula

B. Autotransformer

1. Definition

818

2. Construction



3. Operation

820

QUESTIONS AND PROBLEMS

1. A transformer into which 50 volts is sent in the primary winding and from which 50,000 volts is delivered by the secondary winding:

   a. is a step (up)(down) transformer.

   b. has ________ windings on one side for each winding on the other side.

   c. would step (up)(down) the amperage ______ times.

2. A step-down transformer will step (up)(down) the voltage and step (up)(down) the current.

3. A transformer that would change volts to kilovolts would be a step (up)(down) transformer.

4. The ____________________ is used as a voltage selector.

5. A _____to______ step-up transformer has 70 volts in the primary with a primary current of 20 amperes. The voltage in the secondary will be ____________ and the current will be 20 milliamperes.

6. $T_p = ?$ $T_s = 37{,}000$
   $E_p = 800V$ $E_s = 20V$
   $I_p = 60mA$ $I_s = ?$

7. $T_p = 1400$ $T_s = 560{,}000$
   $E_p = 220V$ $E_s = ?$
   $I_p = ?$ $I_s = 75mA$

820

METERS

OBJECTIVES

State:

1. the purpose of the ammeter, voltmeter.
2. how the ammeter and voltmeter are connected into a circuit.
3. the uses of the ammeter, milliammeter and the milliampere-second meter.

A. Measuring Devices

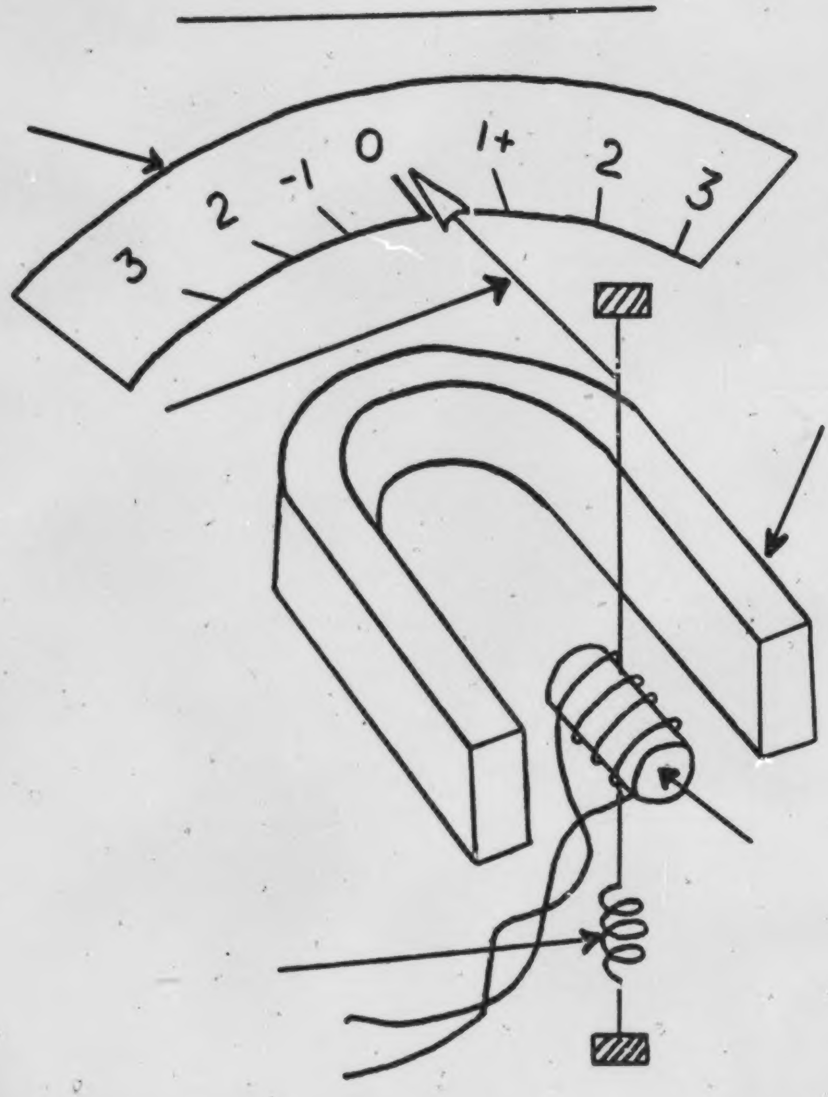
1. Theory

2. Methods

B. Galvanometer

1. Construction

822



2. Theory of Operation

822

C. Ammeter

1. Purposes

2. Construction

3. Types and Uses

D. Voltmeter

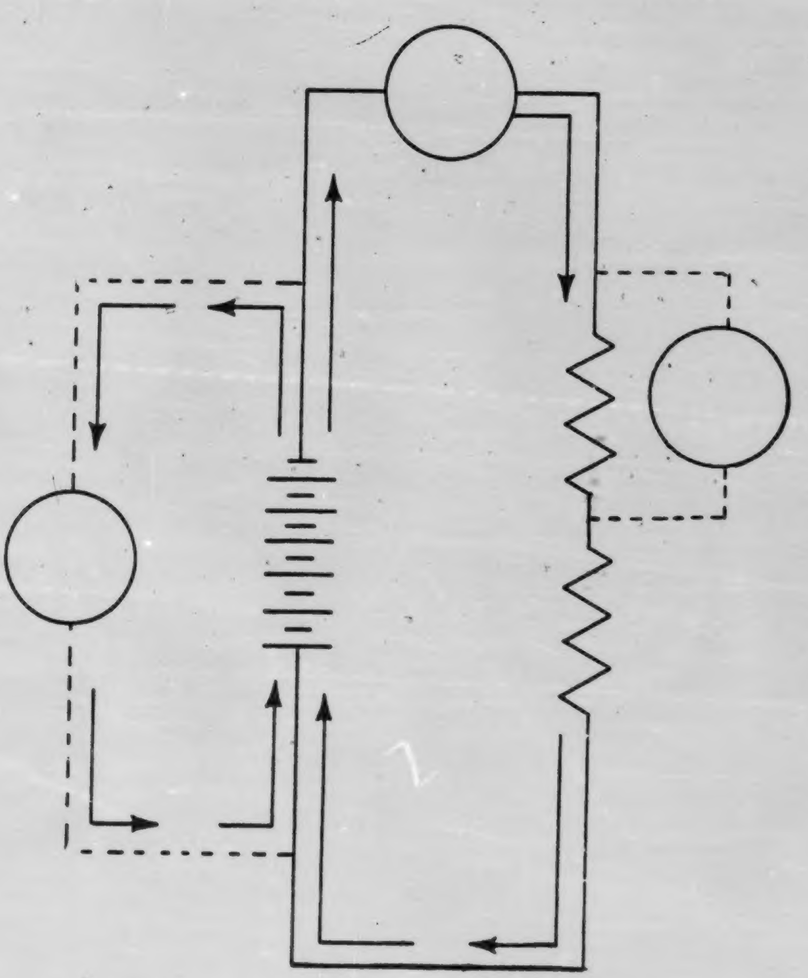
1. Purposes

2. Construction

821

3. **Types**

E. Connecting Meters In Circuits



824

METERS

Electric meters may be designed to measure either voltage or current. There are several variations of both types of meters. When a low-resistance wire (a shunt) is connected in parallel with a galvanometer which has an appropriately calibrated scale, it serves as an ammeter; when a high-resistance wire is connected in series with a galvanometer, it serves as a voltmeter. To measure the voltage or current of an AC additional modification is required, but the same principle is used in AC meters.

The voltmeter is a high-resistance galvanometer used to measure voltage. It measures the drop in potential difference across any two points in an electric circuit and must always be connected in parallel, that is, connected by means of a lead wire to either side of the device across which the voltage drop is to be measured. By increasing its series resistance, a voltmeter can be made to read directly in kilovolts constituting a kilovoltmeter.

In modern high-milliamperage equipment, a ballistic or milliampere-second (mAs) meter is added in series with the regular milliammeter. Owing to the relatively heavy weight of its rotating mechanism, this device has a high degree of inertia which causes the pointer or indicating needle to deflect relatively slowly so that it registers a value equivalent to the mAs (milliampere seconds). In fact, with very short exposures the mA meter often indicates no exposure whatsoever. The mAs meter, due to its design, will give a direct reading in mAs to indicate whether the proper exposure is produced. Ordinarily, the mAs meter does not operate. When it is desired to use the mAs meter, a special button or switch must be held during the exposure to give a reading on the mAs meter. The mAs meter should be used with short exposures only and will usually be found on machines with a capacity of 200mA or more. At exposure times of greater than one second, the ordinary milliammeter gives accurate readings. The mAs meter should never be used for exposures greater than one second because the readings become inaccurate and the meter may be damaged.

826

TIMERS

OBJECTIVES

1. State the reason why the electronic timer is the preferred type of timer.
2. List the four types of timers in order of increasing accuracy and desirability.

A. Purpose

B. Types

1. ______________________________

   a. Construction

   b. Characteristics

2. ______________________________

   a. Construction

   b. Characteristics

826

3. ______________________________

a. Construction

b. Characteristics

4. ______________________________

a. Construction

b. Characteristics

C. Others ---______________________________

1. Construction

828

2. Application

RECTIFICATION

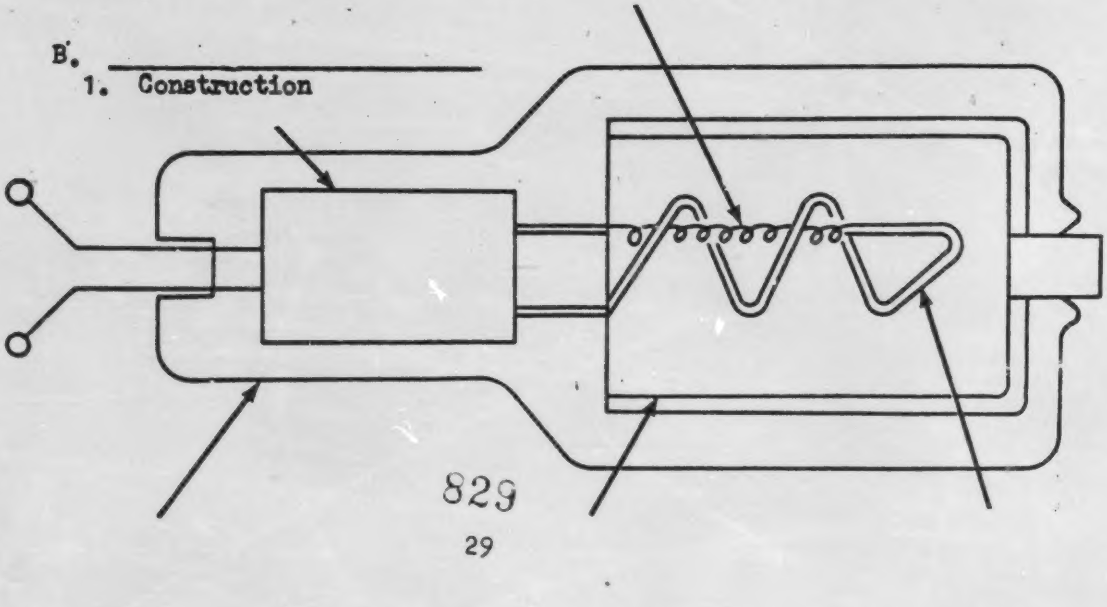
OBJECTIVES

1. Define: Rectification, Valve Tube.
2. State:
   a. the three requirements for valve tube operation.
   b. the type of rectified current which results when using each of the following: self-rectified tubes, single-valve tube rectification, two-valve tube rectification, full-wave rectification.
   c. the uses of the Spin Top.
3. Convert (when given frequency of AC and type of rectification):
   a. impulses to seconds of exposure.
   b. seconds of exposure to impulses.
4. Perform mathematical computations (from memorized relationships) using the Spin Top Timer-Rectification test in any of the following situations:
   a. Given an exposure time, determine how many dots should be produced when using either full-wave or half-wave rectification in either the United States or overseas (four possible situations).
   b. Given the number of dots produced with a given mA value and a specified mode of rectification in a given geographical location, determine:
      1) the exposure time used.
      2) what mAs was produced.
      3) whether the timer was faulty and, if so, whether it runs too fast or too slowly.
      4) whether the rectification system is malfunctioning.
      5) whether a combination of 3 and 4 exists.

A. Rectification-- Definition ______________________________

B. ______________________________

1. Construction

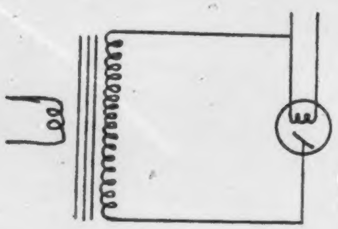


2. Operating Conditions

C. Types of Rectification

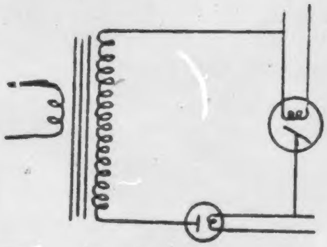
1. ________-__________

a. Theory

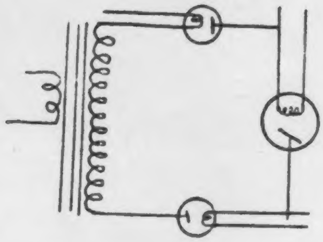


b. Types

(1) ____________________



(2) ____________________



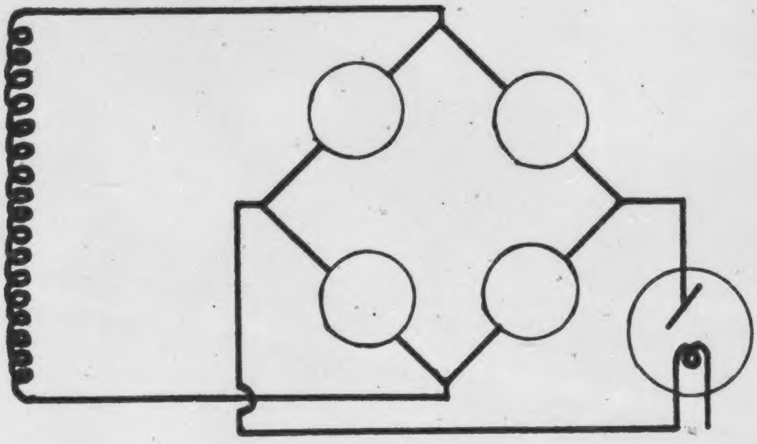
(3) ____________________

829

2. ______-__________

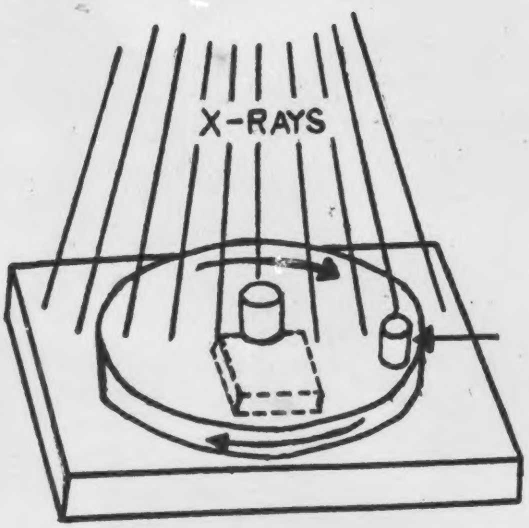
a. Theory

b. Illustration

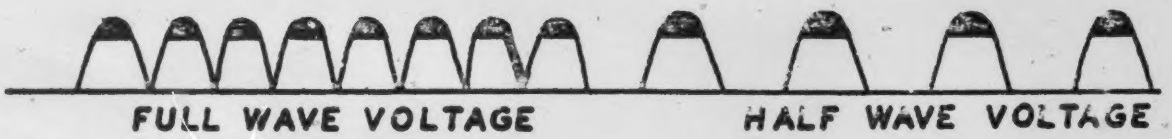


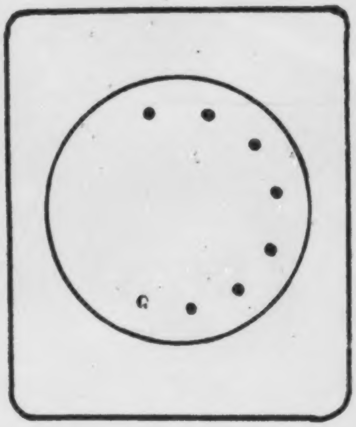
D. Spin-Top Timer Test

1. Construction

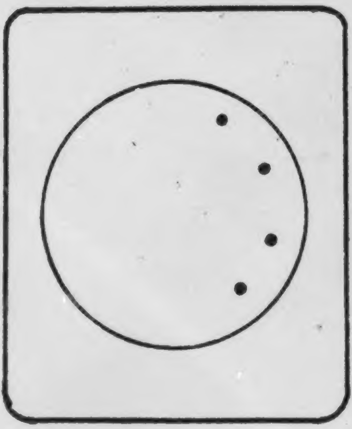


2. Application


FULL WAVE VOLTAGE
HALF WAVE VOLTAGE



FULL WAVE
1/15 S, 8 DOTS
ON FILM



HALF WAVE
1/15 S, 4 DOTS
ON FILM

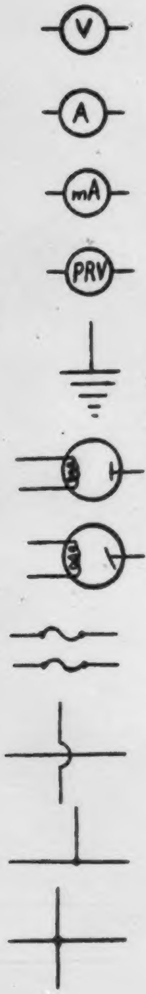
X-RAY MACHINE CIRCUITS

OBJECTIVES

Given a schematic diagram of a basic x-ray machine circuit (refer to page 205) for reference:

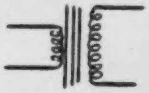
1. Locate any specific component in the diagram when given its name or function.
2. Identify any indicated component in the diagram.
3. Specify the electrical function of any indicated component in the diagram.
4. Identify the sub-circuit of which any component is a member.

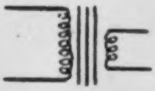
A. Circuit Symbols

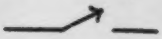


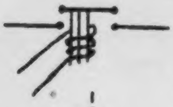
832

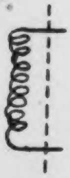
A. Circuit Symbols (continued)

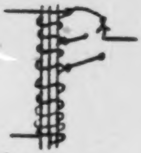


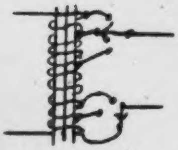


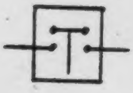


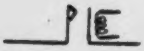


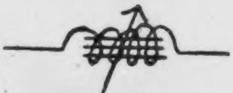


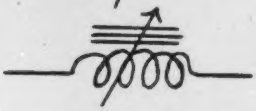










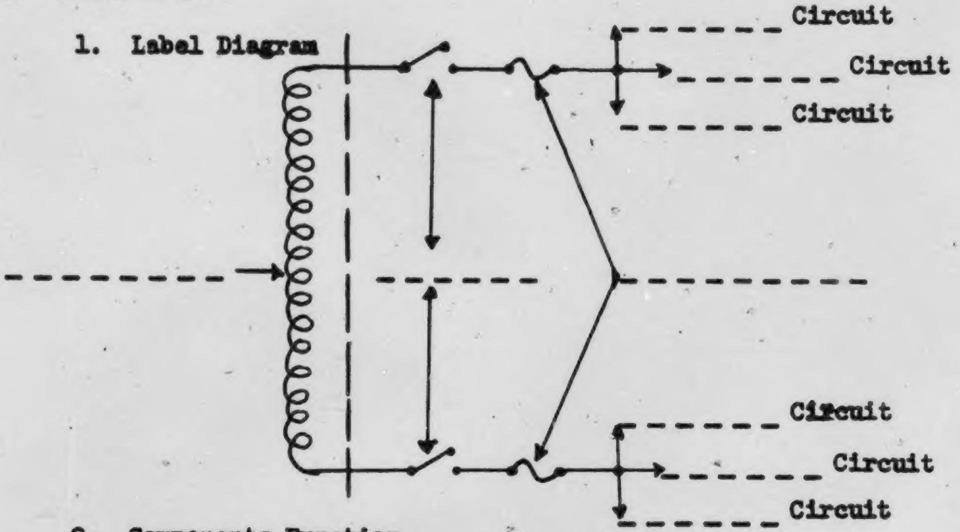


834

833

B. Power Source

1. Label Diagram


Circuit
Circuit
Circuit
Circuit
Circuit
Circuit

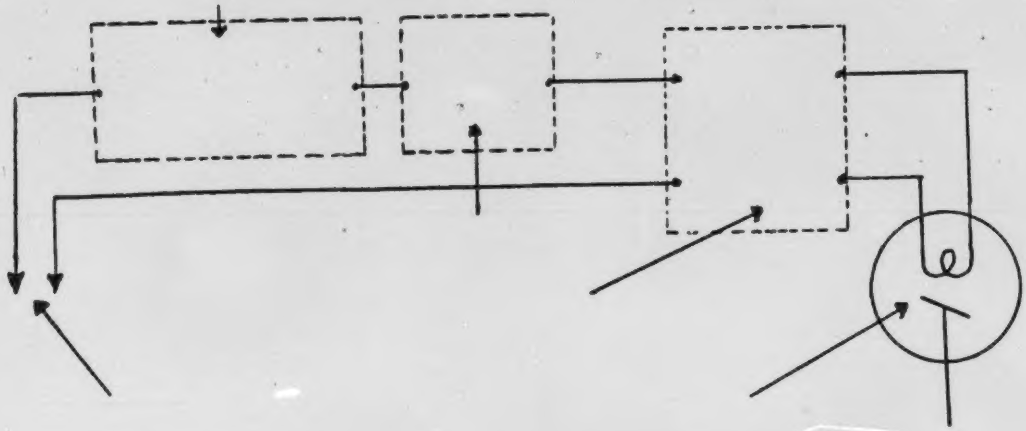
2. Components Function

C. Sub-Circuits

1. ______-____________

a. Function

b. Draw Diagram and Label

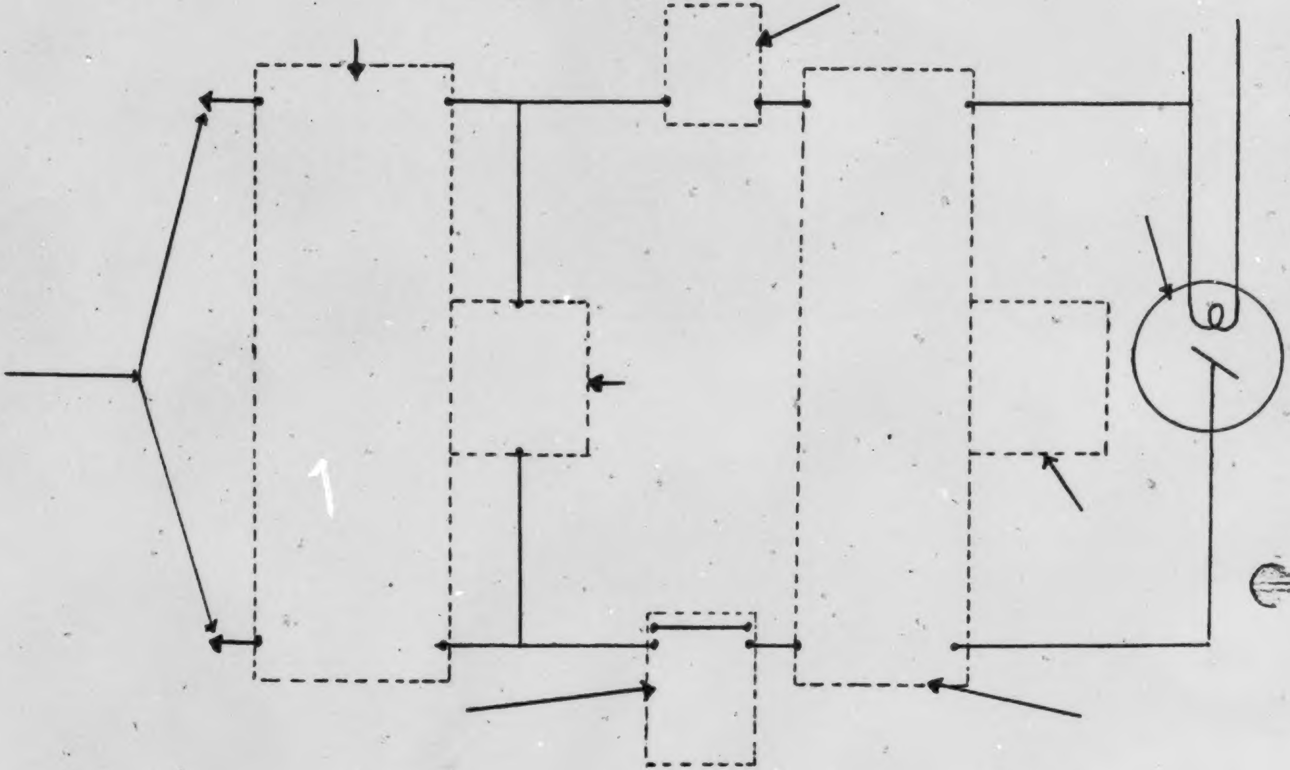


834

2. __________-______________

a. Function

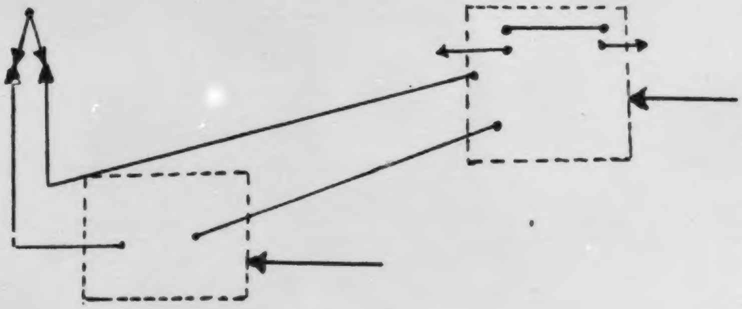
b. Draw Diagram and Label

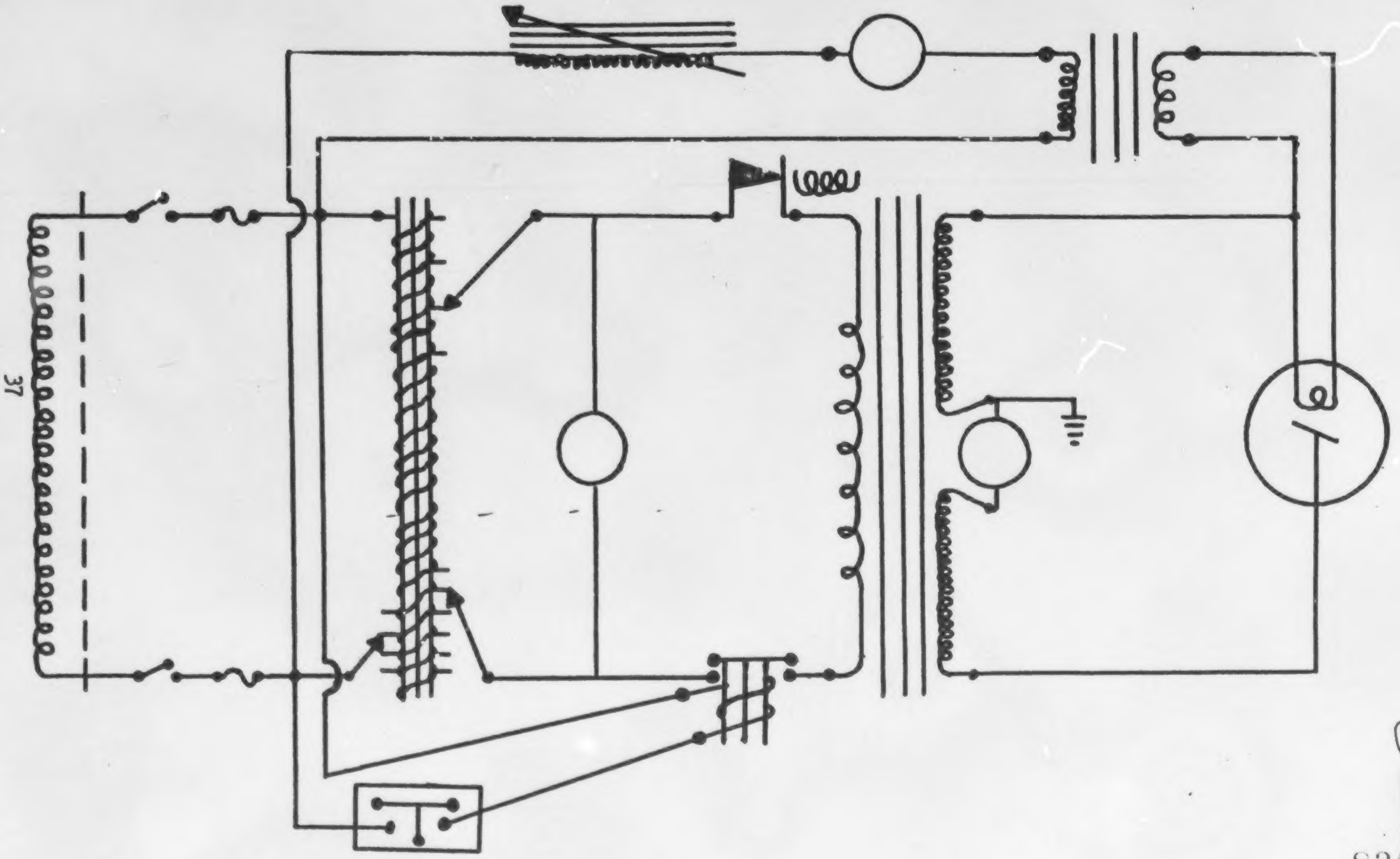


3. __________-__________

a. Function

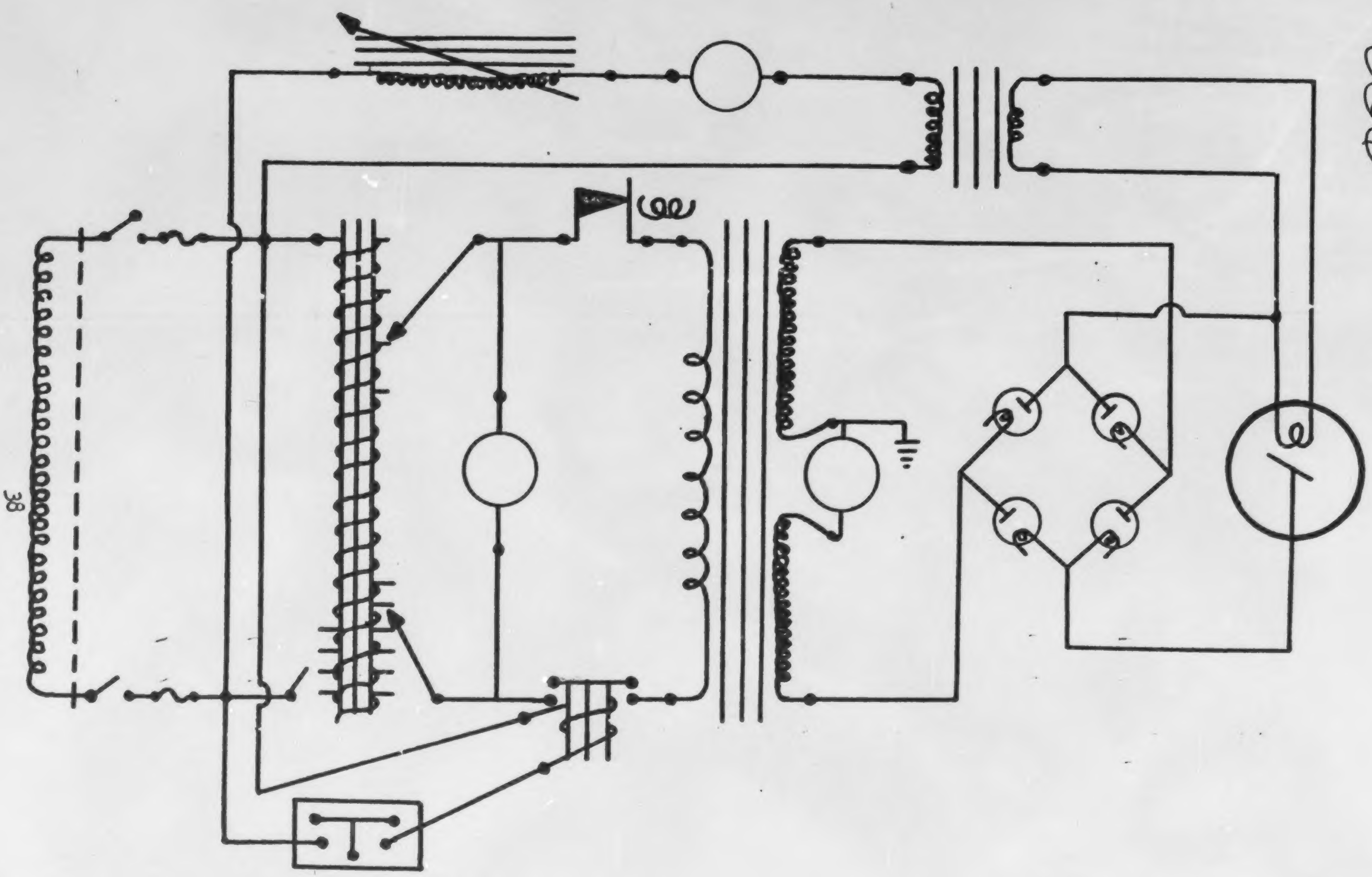
b. Draw Diagram and Label





837 SELF - RECTIFIED : HALF - WAVE X-RAY MACHINE 838

836



FOUR-VALVE - FULL WAVE RECTIFIED X-RAY MACHINE

ELECTRICAL PROTECTION

OBJECTIVES

State:

1. the reason for grounding x-ray equipment.
2. at least two acceptable locations for grounding a portable x-ray machine.
3. the conditions under which electrical arcing is a hazard when using x-ray equipment.

A. Hazards

1. ______________________________

2. ______________________________

3. ______________________________

838

B. Electrocution

1. Effects

2. First Aid

842

SECTION IV - ANNEXES

ANNEX C

RADIOGRAPHIC POSITIONING

Peacetime: 62 hours
Mobilization: 62 hours

OBJECTIVE: *Given a radiographic examination request and access to standard equipment, determine the proper patient administration and institute the principles of radiologic technology to produce diagnostic quality radiographs.

Subject and LP No		Lesson Objective	References
Introduction and Terminology of Positions		Recognize and relate radiographically the concepts of right angle viewing of radiographs. Recognize terms used in the naming of positions and the positioning of the patient. Recognize terms used in the explanation, demonstration, and application of positions. Given a position, set up proper machine factors from the factor chart.	TM 8-280, pp 10-1 thru 10-5, para 10-1 thru 10-6.
Film Identification: Captioning		Select the 9 items on the X-ray request slip (SF 519A) that must be filled out before it can be processed by the receptionist. Identify two primary methods of transmitting permanent identification to a radiograph. Select the 4 items of patient information required to properly identify a radiograph. Given a description of a position, determine the proper letter marker to be used. Given radiographs of the trunk and skull, determine, by letter marker, the position of the part.	TM 8-280, pp 10-5, para 10-7.
Exposure Room Orientation		Carry out the normal sequence of activities in the laboratory phase of instruction. Describe expected conduct during the laboratory phase. Locate essential areas of activity in the X-ray laboratory.	None.

Subject and LP No	Lesson Objective	References
Order of Procedure: Demonstration	Determine the X-ray technologist's role in performing a radiographic procedure. Identify in sequence the order of procedure required for radiographic positioning. After practice, apply the order of procedure in proper sequence while positioning the patient to produce diagnostic radiographs.	TM 8-280, para 10-15.
Positioning of the Upper Extremity: Hand	Identify by name the position and anatomical structures demonstrated. Determine the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization film identification and captioning necessary to demonstrate the position. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiographic position.	TM 8-280, pp 10-8 thru 10-11; para 8-12, pp 8-10.
Positioning of the Upper Extremity: Wrist	Identify by name the position and anatomical structures demonstrated. Determine the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization film identification and captioning necessary to demonstrate the position. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data	TM 8-280, pp 8-10 thru 8-13, para 8-12; pp 10-12 thru 10-14.

Subject and LP No	Lesson Objective	References
Positioning of the Upper Extremity: Forearm	Identify by name the position and anatomical structures demonstrated. Determine the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of central ray, FFD, alignment, breathing technique, immobilization film identification and captioning necessary to demonstrate the position. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiographic position.	TM 8-280, pp 8-13 thru 8-14, para 8-13, pp 10-15 thru 10-16.
Positioning of the Upper Extremity: Elbow	Identify by name the position and anatomical structures demonstrated. Determine the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of central ray, FFD, alignment, breathing technique, immobilization film identification and captioning necessary to demonstrate the position. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiographic position.	TM 8-280, pp 8-15, fig 8-17, p 8-18, para 8-17, pp 10-17 thru 10-20.
Positioning of the Upper Extremity: Humerus	Identify by name the position and anatomical structures demonstrated. Determine the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing	TM 8-280, p 8-14, para 8-14, pp 10-21, 10-22, 10-24.

Subject and LP No	Lesson Objective	References
	technique, immobilization film identification and captioning necessary to demonstrate the position. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiographic position.	
Positioning of the Upper Extremity: Shoulder	Identify by name the position and anatomical structures demonstrated. Determine the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization film identification and captioning necessary to demonstrate the position. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiographic position.	TM 8-280, pp 8-14 thru 8-18, para 8-15, p 10-25.
Positioning of the Shoulder Joint	Identify by name the position and anatomical structures demonstrated. Determine the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization film identification and captioning necessary to demonstrate the position. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data	TM 8-280, pp 8-14 thru 8-18, para 8-15,

Subject and LP No	Lesson Objective	References
	which would produce a technically acceptable radiographic position.	
Positioning of the Upper Extremity: Scapula	Identify by name the position and anatomical structures demonstrated. Determine the correct routine, PFR/CRPR, film rundown, conefield angle and direction of the central ray, FFD, alignment, breathing technique, immobilization film identification and captioning necessary to demonstrate the position. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiographic position.	TM 8-280, pp 8-14 thru 8-18, para 8-15, pp 10-26, 10-27.
Positioning of the Upper Extremity: Clavicle	Identify by name the position and anatomical structures demonstrated. Determine the correct routine, PFR/CRPR, film rundown, conefield angle and direction of the central ray, FFD, alignment, breathing technique, immobilization film identification and captioning necessary to demonstrate the position. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiographic position.	TM 8-280, pp 8-14 thru 8-18, para8-15, p 10-28.
Film Discussion: Upper Extremity	Identify the routine and additional views on radiographs. Given a radiograph of an upper extremity position, select the pertinent	Prev instr.

Subject and LP No	Lesson Objective	References
	information necessary to produce that position; identify and discuss any error(s) demonstrated on the radiograph; identify anatomical structures demonstrated.	
Positioning of the Lower Extremity: Foot	Identify by name the position and anatomical structures demonstrated. Determine the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization film identification and captioning necessary to demonstrate the position. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiographic position.	TM 8-280, pp 8-19 thru 8-21, para 8-21, pp 10-30 thru 10-32.
Positioning of the Lower Extremity: Os Calcis	Identify by name the position and anatomical structures demonstrated. Determine the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization film identification and captioning necessary to demonstrate the position. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiographic position.	TM 8-280, p 8-19, para 8-21(1). pp 10-36.

Subject and LP No	Lesson Objective	References
Positioning of the Lower Extremity: Ankle	Identify by name the position and anatomical structures demonstrated. Determine the correct routine, PFR/CRPR, film rundown, conefield angle and direction of the central ray, FFD, alignment, breathing technique, immobilization film identification and captioning necessary to demonstrate the position. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiographic position.	TM 8-280, p 8-25, para 8-25 f & g, pp 10-33 thru 10-35.
Positioning of the Lower Extremity: Leg	Identify by name the position and anatomical structures demonstrated. Determine the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization film identification and captioning necessary to demonstrate the position. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning date which would produce a technically acceptable radiographic position.	TM 8-280, pp 8-21 thru 8-22, para 8-22, pp 10-37 thru 10-38.
Positioning of the Lower Extremity: Knee	Identify by name the position and anatomical structures demonstrated. Determine the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment,	TM 8-280 8-22, para 8-23, pp 10-39 thru 10-41.

Subject and LP No	Lesson Objective	References
	breathing technique, immobilization film identification and captioning necessary to demonstrate the position. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiographic position.	
Positioning: Knee (Holmblad and Beclere)	Identify by name the position and anatomical structures demonstrated. Determine the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization film identification and captioning necessary to demonstrate the position. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiographic position.	TM 8-280, p 8-22, para 8-23, p 10-42.
Positioning: Knee (Settegast)	Identify by name the position and anatomical structures demonstrated. Determine the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization film identification and captioning necessary to demonstrate the position. Given a request slip and a simulated patient in the X-ray laboratory, select the	TM 8-280, p 8-22, para 8-23, p 10-43.

Subject and LP No	Lesson Objective	References
	proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiographic position.	
Positioning of the Lower Extremity: Femur	Identify by name the position and anatomical structures demonstrated. Determine the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization film identification and captioning necessary to demonstrate the position. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiographic position.	TM 8-280, p 8-22, para 8-23, pp 10-44 thru 10-45.
Positioning of the Lower Extremity: Pelvis	Identify by name the position and anatomical structures demonstrated. Determine the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization film identification and captioning necessary to demonstrate the position. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiographic position.	TM 8-280, pp 8-23 thru 8-24, para 8-24, pp 10-49

Subject and LP No		Lesson Objective	References
Positioning of the Lower Extremity: Hip		Identify by name the position and anatomical structures demonstrated. Determine the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization film identification and captioning necessary to demonstrate the position. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiographic position.	TM 8-280, pp 8-25 thru 8-27, para 8-25, pp 10-26 thru 10-48.
Position of the Sacrum		Identify by name the position and anatomical structures demonstrated. Determine the correct routine, PFR/CRPR film rundown, conefield angle and direction of the central ray, FFD, alignment, breathing technique, immobilization film identification and captioning necessary to demonstrate the position. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiographic position.	TM 8-280, p 8-32, para 8-34, pp 10-78 thru 10-79.
Positioning of the Coccyx		Identify by name the position and anatomical structures demonstrated. Determine the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization film identification and captioning necessary	TM 8-280, p 8-32, para 8-35, p 8-33, pp 10-78 and 10-79.

852

Subject and LP No	Lesson Objective	References
	to demonstrate the position. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiographic position.	
Film Discussion: Lower Extremity	Identify the routine and additional views on radiographs. Given a radiograph of a lower extremity position, select the pertinent information necessary to produce that position; identify and discuss any error(s) demonstrated on the radiograph; identify anatomical structures demonstrated.	Prev. Instr.
Positioning of the Trunk: Cervical Spine	Identify by name the position and anatomical structures demonstrated. Determine the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization film identification and captioning necessary to demonstrate the position. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiographic position.	TM 8-280, pp 8-29 thru 8-33, pp 10-67 thru 10-69.
Positioning of the Oblique, Flexion and Extension Cervical Spine	Identify by name the position and anatomical structures demonstrated. Determine the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the	TM 8-280 pp 8-29 thru 8-33, pp 10-69, 10-70.

Subject and LP No	Lesson Objective	References
	central ray, FFD, alignment, breathing technique, immobilization film identification and captioning necessary to demonstrate the position. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiographic position.	
Positioning of the Trunk: Dorsal Spine	Identify by name the position and anatomical structures demonstrated. Determine the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization film identification and captioning necessary to demonstrate the position. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiographic position.	TM 8-280, pp 8-29 thru 8-33, pp 10-72 thru 10-73.
Positioning of the Trunk: Lumbar Spine	Identify by name the position and anatomical structures demonstrated. Determine the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization film identification and captioning necessary to demonstrate the position. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors,	TM 8-280, pp 8-29 thru 8-33, pp 10-75 thru 76.

Subject and LP No	Lesson Objective	References
	accessory equipment and the correct positioning data which would produce a technically acceptable radiographic position.	
Positioning of the Trunk: Lumbosacral Articulation	Identify by name the position and anatomical structures demonstrated. Determine the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization film identification and captioning necessary to demonstrate the position. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiographic position.	TM 8-280, p 8-32, para 8-34, pp 10-78 thru 10-79.
Positioning of the Oblique Sacroiliac Articulation, Oblique Lumbar and Dorsal Spine	Identify by name the position and anatomical structures demonstrated. Determine the correct routine, PFR/CRPR, film rundown, conefield angle and direction of the central ray, FFD, alignment, breathing technique, immobilization film identification and captioning necessary to demonstrate the position. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiographic position.	TM 8-280 pp 8-29 thru 8-35, pp 10-74, 10-77, 10-80.

Subject and LP No	Lesson Objective	References
Positioning of the Trunk: Chest	Identify by name the position and anatomical structures demonstrated. Determine the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization film identification and captioning necessary to demonstrate the position. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiographic position.	TM 8-280 pp 8-59 thru 8-61, para 8-72 thru 8-80, pp 10-52 thru 10-55.
Positioning of the Trunk: Ribs	Identify by name the position and anatomical structures demonstrated. Determine the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization film identification and captioning necessary to demonstrate the position. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiographic position.	TM 8-280, pp 8-34, Fig 8-35; p 8-35, para 8-40, pp 10-58 thru 10-60.
Positioning of the Trunk: Abdomen	Identify by name the position and anatomical structures demonstrated. Determine the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization film identification	TM 8-280, pp 8-42 and 8-44 para 8-50 and 8-52, pp 8-48 thru 8-55, para 8-60 thru 8-68,

Subject and LP No	Lesson Objective	References
	and captioning necessary to demonstrate the position. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiographic position.	pp 10-64 and 10-65.
Positioning of the Sternum	Identify by name the position and anatomical structures demonstrated. Determine the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization film identification and captioning necessary to demonstrate the position. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiographic position.	TM 8-280, pp 8-32 and 8-34, para 8-38, Fig 8-35, p 8-37, Fig 8-37, pp 10-61 and 10-62.
Positioning of the Clavicular Joints	Identify by name the position and anatomical structures demonstrated. Determine the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization film identification and captioning necessary to demonstrate the position. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data	TM 8-820, p 8-17 Fig 8-19; p 8-18, Fig 8-20, para 8-16, p 8-19 Fig 8-21; p 8-20, Fig 8-22, pp 10-29 and 10-63.

Subject and LP No	Lesson Objective	References
	which would produce a technically acceptable radiographic position.	
Film Discussion: Trunk	Identify the routine on radiographs. Given a radiograph of a trunk position, select the pertinent information necessary to produce that position; identify and discuss any error(s) demonstrated on the radiograph; identify anatomical structures demonstrated.	Prev instr.
Positioning of the Skull: Cranium	Identify by name the position and anatomical structures demonstrated. Determine the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization film identification and captioning necessary to demonstrate the position. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiographic position.	TM 8-280, pp 8-40 and 8-41, para 8-46 and 8-47, pp 10-81 thru 10-85.
Positioning of the Skull: Sinus	Identify by name the position and anatomical structures demonstrated. Determine the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immovilization film identification and captioning necessary to demonstrate the position. Given a request slip and a simulated patient in the X-ray laboratory, select the	TM 8-280, p 8-41, para 8-48 and p 8-45, Fig 8-45, pp 10-86 thru 10-88.

Subject and LP No	Lesson Objective	References
	proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiographic position.	
Positioning of the Skull: Mandible	Identify by name the position and anatomical structures demonstrated. Determine the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization film identification and captioning necessary to demonstrate the position. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiographic position.	TM 8-280 p 8-39, para 8-43(h), pp 8-40 and 8-41, Fig 8-39 and 8-40, pp 10-99 thru 10-102.
Film Discussion: Cranium-Skull and Supplemental Positions	Identify the routine and additional views on radiographs. Given a radiograph of a skull and supplemental position, select the pertinent information necessary to produce that position; identify and discuss any error(s) demonstrated on the radiograph; identify anatomical structures demonstrated.	Prev instr.
Positioning of the Skull: Mastoid and Temporomandibular Joint	Identify by name the position and anatomical structures demonstrated. Determine the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization film identification and captioning necessary to	TM 8-280, p 8-39, para 8-45, pp 8-40 and 8-41, Fig 8-39 and 8-40, pp 10-86 and 10-87.

Subject and LP No	Lesson Objective	References
	demonstrate the position. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiographic position.	
Positioning of the Skull: Nose and Facial Bones	Identify by name the position and anatomical structures demonstrated. Determine the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization film identification and captioning necessary to demonstrate the position. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiographic position.	TM 8-280, pp 8-40 thru 8-42, para 8-46 thru 8-49, Fig 8-39 thru 8-42; pp 8-44, Fig 8-43 and 8-44, pp 10-98 and 10-107.
Positioning of the Skull: Petrous Ridges	Identify by name the position and anatomical structures demonstrated. Determine the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization film identification and captioning necessary to demonstrate the position. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiographic position.	TM 8-280, p 8-36, para 8-42c(4), p 8-43, Fig 8-42, p 10-81, Fig 10-75, pp 10-94 and 10-95.

860

857

Subject and LP No	Lesson Objective	References
Positioning of the Skull: Zygomatic Arches and Rhese's Foramen	Identify by name the position and anatomical structures demonstrated. Determine the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization film identification and captioning necessary to demonstrate the position. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiographic position.	TM 8-280, p 8-38, para 8-42e(1), p 8-39, para 8-43b&c, pp 10-91 and 10-106.

861

858

SFC Binkley

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

*LP 38-520-027
056

Introduction and Terminology of Positions (2 hour)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES: TM 8-280, p 10-1 thru 10-5.

STUDY ASSIGNMENT: After class study GR 38-520-027-1 and review TM 8-280, p 10-1 thru 10-5.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 and GR 38-520-027-1

TOOLS, EQUIPMENT AND MATERIALS: GR 38-520-027-1 issued at beginning of class (one per student)

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Chalk, chalkboard, eraser; PA system with lapel mike; Radiographs of skull, chest and leg, radiographic illuminator, reference to positioning terminology and Optimum kVp technic chart (see Anneses A and B).

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENT: None

TYPE OF INSTRUCTION: Lecture

I. INTRODUCTION (2 min)

A. Opening statement: Our purpose is to introduce the subject matter that will be covered during the basic and special procedures phase of your training. We will review certain terms and introduce others that are pertinent to x-ray positioning. Questions such as, "What is required of me as a student? Why do we take certain views of a part? What technical factors will be used?", will be answered during this period.

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*This lesson plan supersedes LP 38-520-0[illegible] 064

859

B. Objectives

1. Define and relate radiographically the concepts of right angle viewing of radiographs.

2. Recognize and define terms used in the naming of positions and the positioning of the patient.

3. Recognize and define terms used in the explanation, demonstration and application of positions.

4. Given a position, set up proper machine factors from the factor chart.

C. Class procedure and lesson tie-in

None

II. EXPLANATION (40 min)

NOTE: Issue GR 38-520-027-1, one per student.

A. Instructional Procedures

1. Classroom

a. Conduct

b. Class procedures

(1) Explanation/demonstration of positions

(2) Film discussions

(3) Examinations

(4) Quizzes

2. Laboratory

a. Student patient-technician role

b. Instructor role

c. Grading (Crucial Objective)

d. Quizzes

NOTE: Refer students to GR 38-520-027-1.

B. Right angle radiographic viewing.

1. Concepts (three dimensional)

a. Radiographic visualization

NOTE: Show posterior-anterior radiograph of skull with foreign body.

(1) Posterior-anterior (PA) view

(a) Height--Superior to inferior

(b) Width--Lateral to lateral

NOTE: Show lateral radiograph to posterior-anterior skull with foreign body.

(2) Lateral view

(a) Height--Superior to inferior

(b) Length--Anterior to posterior

QUESTION: The PA and lateral views of the skull afford three dimensions: What are they?

ANSWER: Depth, width and length.

2. Steroscopy procedure

NOTE: Steroscopy procedures may be used when right-angle viewing cannot be obtained or in addition to right-angle viewing (PA and lateral). This procedure will be demonstrated later in the course.

NOTE: Instructor emphasize, if lateral cannot be accomplished for a right-angle projection to the PA or AP view, the next choice would be an oblique view.

3. Naming positions

a. Entry-exit surface of the central ray.

b. Anatomical surface nearest the film.

c. The author or originator.

d. Anatomical structure demonstrated.

4. Positioning terminology

NOTE: Instructor review the following terms:

a. PA--AP

b. Lateral

c. Obliques

d. (1) RAO--LAO

(2) RPO--LPO

e. Supine--prone

f. Recumbent--decubitis

5. Explanation/Application (classroom-laboratory terms)

NOTE: Refer to Annex A for explanation

6. Factor Chart

NOTE: Refer to Annex B for explanation

C. Questions from students

NOTE: After class study TM 8-280, p 10-1 thru 10-5 and GR 38-520-027-1.

III. SUMMARY (3 min)

A. Review main points

1. Classroom/laboratory procedures

2. Concepts of right-angle viewing

3. Naming positions

4. Explanation/application of positioning terminology

5. Factor chart

B. Closing Statement: You now have the format of the positioning phase; in addition to the terminology, we will use in the explanation, demonstration and application of radiographic positioning. Do not forget that our mission is to serve the sick, and our best efforts will assure that his clinical needs are met.

ANNEX A
INSTRUCTIONAL AIDS

Introduction and Terminology of Positions

The following terms are used daily in the explanation, demonstration and in the application of radiographic positions.

Routine:

Refers to the necessary radiographic positions or views needed to accomplish right-angle viewing and/or a general survey of the anatomical part to be demonstrated.

Additional views:

Positions or views in addition to the routine for a more thorough visualization of the part and/or specific structures.

PFR (Part to Film-holder Reference):

Refers to the specific placement of a palpation point or anatomical part on the film holder to properly demonstrate the part.

EXAMPLE: To demonstrate the lateral view of the hand the PFR would be: The head of the second metacarpal to center of the film (holder).

CRPR(Central Ray to Part Reference):

Relates to the specific placement of the central-ray to an anatomical part or palpation point thereby projecting that part or point to center of the film (holder).

Film Rundown:

Refers to the film holder requirements for a procedure (routine or additional views) with reference to the film holder size (8 x 10, 10 x 12, or 14 x 17); the film holder placement in relation to the anatomical part (lengthwise (LW), or crosswise (CW) and whether the use of a grid (B) or non-grid (NB) accessory is necessary. The film rundown for an individual view of a routine will refer to the film rundown of the routine.

EXAMPLE: The routine hand film rundown is: 10 x 12, CW, NB. Thus, the film rundown for the oblique hand is: 10 x 12, CW, NB.

863

CR (Central Ray):

Refers to the angle and direction of the central ray (CR) with relation to the film holder or other reference. The central ray is always to center of the film area to be exposed whether a PFR or CRPR is used. When using a PFR, the CR is positioned to strike the center of the film being exposed. For CRPR's the film is adjusted so the CR would strike center of the film to be exposed.

Conefield:

Reference to the film area being exposed by the primary x-ray beam.

1. Film coverage--any area being exposed whether it be 1/4, 1/3, 1/2, or the whole film holder; thus, the conefield requirements for the PA hand would be film coverage.

2. All other conefields--the size of the diameter of the field will be specified.

   EXAMPLE: The conefield requirements for the open-mouth cervical is specified as six inches.

FFD (Focal Film Distance):

Measured distance in inches between the tube focal spot and the film holder. The following applies:

Table-top procedures--FFD is measured through the film holder to the table top.

Bucky procedures--FFD is measured to table top at a measurement allowing two inches to the Bucky tray. For example: If a 40 inch FFD is required for a Bucky technique, a measured distance of 38 inches to the table top is set; thus leaving two inches from the table top to Bucky tray where the film holder is placed resulting in a total distance of 40 inches FFD.

Breathing Technique:

Required instructions given to the patient prior to making the exposure. Following the exposure, it should always be remembered that the patient be instructed to breathe normally. The types of breathing instructions are as follows:

1. Suspended Respiration--Patient instructed to stop breathing at anytime.

267

2. Suspended Inspiration--Patient instructed to take in a deep breath and hold in the breath during the exposure.

3. Suspended Expiration--Patient instructed to take in a breath and let his breath out and holding out his breath during the exposure.

Demonstrates:

Refers to the primary and surrounding anatomical structures that are demonstrated on the radiograph.

Alignment:

The necessary position of certain anatomical structures and/or anatomical planes relationship to the film, other anatomical planes, etc.--to properly demonstrate the part.

EXAMPLE: To properly demonstrate the AP elbow, the epicondyles of the humerus must be parallel to the film.

Cassette:

Refers to film holder. In x-ray, the cassette is a special type of holder. Generally, the top of the cassette is black (bakelite) framed by a metal border. In the use of FFR's the metal border is included in the measurement. Conefields also include the exposing metal borders. Cassettes with bakelite tops of other colors (generally orange or red) are grid cassettes where the grid is included in the bakelite. These should be compensated for in technique as for Bucky procedures.

865

ANNEX B
INSTRUCTIONAL AIDS

ACADEMY OF HEALTH SCIENCES, US ARMY
MEDICINE AND SURGERY DIVISION
X-RAY BRANCH
FORT SAM HOUSTON, TEXAS 78234

Optimum kVp Technic Chart 100 mA, 100 kVp Field Unit

This Optimum kVp Technique Chart is primarily for use with the full wave rectified 100 mA, 100 kVp, (stationary anode) field unit with the Army field table. Film holders on this chart are cassettes with high speed screens. The Bucky used is 6:1 where indicated by a "B" in the last column. An asterisk (*) indicates non-routine positions. A double asterisk indicates a position for which factor compensations for patients above the normal centimeter range will exceed tube limits. Use the blocked chart below to adjust for centimeter measurements above or below the centimeter range shown.

NOTE: This chart is valid for any radiographic unit when employing optimum kVp technique. Compensations for higher grid ratios should be made in kVp.

3-5 cm. below	1-2 cm. below	In range	1-2 cm. above	3-5 cm. above
1/2 x s	2/3 x s	basic s	basic s x 1 1/2	basic s x 2

PART	POSITION	FILM	cm	kV	FOCAL SPOT	mA	s	FFD	B	NB
HAND	PA	1/2 10C	2-4	50	Sm	25	.2	40		NB
	Oblique	1/2 10C	3-5	50	Sm	25	.2	40		NB
	Lateral*	1 8L	7-10	50	Sm	20	.6	40		NB
WRIST	PA	1/4 10C	3-5	50	Sm	25	.2	40		NB
	Oblique	1/4 10C	4-6	55	Sm	25	.2	40		NB
	Lateral	1/4 10C	5-8	50	Sm	20	.6	40		NB
	PA w/Ulnar flexion	1/4 10C	3-5	50	Sm	25	.2	40		NB
FOREARM	Dist, AP	1/2 10L	4-7	60	Sm	25	.2	40		NB
	Dist, Lateral	1/2 10L	6-9	60	Sm	25	.3	40		NB
	Prox, AP	1/2 10L	6-9	60	Sm	25	.3	40		NB
	Prox, Lateral	1/2 10L	7-10	60	Sm	25	.3	40		NB
ELBOW	AP	1/2 10C	6-9	60	Sm	25	.3	40		NB
	Lateral	1/2 10C	6-9	60	Sm	25	.3	40		NB
	Jones*	1 8L	8-11	60	Sm	25	.4	40		NB
HUMERUS	Dist, AP	1/2 10L	7-10	60	Sm	25	.3	40		NB
	Dist, Lateral	1/2 10L	7-10	60	Sm	25	.3	40		NB
	Full, AP, EX	1/2 14L	7-11	60	Sm	25	.3	40		NB
	Full, AP, IN	1/2 14L	7-11	60	Sm	25	.3	40		NB
	Trans Thoracic*	1 10L	35-40	80	Lg	100	1.5	40	B	

866

ACADEMY OF HEALTH SCIENCES, US ARMY *IM 38-520-027
DIVISION OF MEDICINE AND SURGERY 056
X-RAY BRANCH

Introduction and Terminology of Positions

The purpose of this hour is to introduce you to the subject matter to be covered during the basic and advanced positioning phase of this school. We will review certain terms and introduce others that are pertinent to x-ray positioning, and inform you of what is required of you as a student. Why do we take certain views of a part? What is to be achieved in taking more than one view? These questions will be answered during this hour.

The term "basic positioning" simply means the common day-by-day positions that the X-Ray Specialist performs. First, we would like to point out the importance of positioning. In our present day x-ray clinics, we have the latest equipment that money can buy. There is a machine that after you have set the nominal figure for the exposure, you simply press a button, and when the part has had enough exposure the machine automatically shuts off by itself. We have a darkroom processor that will completely process the x-ray film in 90 seconds from the time you place the film into it. After 90 seconds, the radiograph is ready to be read, and completely dry. With all the fancy equipment that we do have in our modern Army x-ray clinics, there is one that we do not have. We do not have machines that will take the patient as he enters the clinic, have the patient dress for the examination, put that patient on the table, direct the tube to the specific spot, and press the exposure button. This is where you come in. In this basic positioning phase of instruction, we are going to train you to be X-Ray Specialists.

As a result of this instruction, you will be able to comprehend the facts pertaining to basic positionings according to the standards of the school. Our learning phase is no different than any other. First, we are going to show you how to do it; then you are going to do it. We will then critique what has been done, and later, you will be given examinations to make sure that you thoroughly understand the procedure.

Before you are actually required to do work in the laboratory, you will know every aspect of the machinery located there. For a portion of each laboratory period, one student will act as the X-Ray Specialist while the second student will act as the patient. After he finishes each request or, in the case of more than one view of the film, a part of that request, the instructor will critique thoroughly what has been done. You understand that in this applicatory phase of training, there is no actual radiation emerging from the tube. We accomplish every step of the procedure as if there were

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*This instructor's manuscript supersedes IM 38-520-027, 064

867

actual X-rays. There will be no doubt in your mind about the final result of your film once the instructor has shown you in detail the discrepancies that you have made in your procedure. After the first student has accomplished his assignment for the day, the second student will begin.

Examinations play a very important part in our learning process. You will find that in addition to the weekly test that you are accustomed to, you will have a daily-type test occasionally. The purpose of these daily-type tests is to insure that you are keeping abreast with study assignments and that you are up to date on previous material that has been taught. Naturally, they count as a part of your total grade.

The remainder of this hour concerns terms and facts that are pertinent to "basic positioning." It may be that you have heard of some of these terms previously. It may be that some of these terms are entirely foreign to you. Simply listen and take notes as you see fit. At this time, please refer to your GR 38-520-027-1, beginning on page one.

This is a radiograph. From your knowledge of anatomy, you can easily tell that it is some position of the skull. What can a roentgenologist see in this position of the skull? He can see height, and he can see width. We call height superior-to-inferior, and width lateral-to-lateral. As my pointer moves across the skull, you can see it traversing a foreign object within the skull. What do we see in that foreign object: We see height and width. In both the case of the skull and the foreign body, there is a dimension lacking. That dimension is depth, in this case from anterior to posterior. We can tell the length both of the skull and of the foreign object and we can tell the width, but we cannot tell how far within the skull this foreign object is; neither can we tell the depth of the foreign object itself. In any single radiograph of any given part, this same principle holds true.

Here you see a different projection of that same part. The lateral view of that same part. We can see length and we can see width. That height again is superior-to-inferior. That length now is from anterior to posterior. But again something is lacking. We cannot see depth. Depth in this case is from lateral to lateral.

As we see these two together, there is nothing lacking. All three dimensions are included. How was this accomplished? This was done by taking two views of the same part with a 90-degree rotation between the two projections. This turn was accomplished by moving the part 90 degrees from its first position. This total procedure has a name. It is called "right-angle viewing." It is the common method of three-dimensional viewing of a part. There is another method of three-dimensional viewing which is called "stereoscopy." It is a much more special and elaborate procedure and will be taught at a later date in this course. In Army

871

clinics, right-angle viewing is the usual procedure for viewing of any part. There are some exceptions to this, but in the main, right-angle viewing is the basis for routine projection for most body parts.

Each of the projections that you saw on the viewbox a moment ago has a name. You are already familiar with some of those names.

An X-ray position may be referred to in different ways. For example, it may be named after the originator of the position, the anatomical structure demonstrated, the anatomical surface in contact with the film, or named by the anatomical surfaces through which the central ray enters and exits the part. The latter is the most common way in which a position is named.

The following terms used to name positions are acceptable because each conveys an exact and specific meaning. Anteroposterior (AP) indicates that the central ray (CR) entered the anterior surface of the part and emerged from the posterior surface. Posteroanterior (PA) indicates that the CR entered the posterior surface and emerged from the anterior surface. Thus, a "PA" projection of the cranium is made with the CR entering the posterior surface of the cranium and emerging from the anterior surface, whereas an "AP" projection of the cranium is made with the CR passing from the anterior to the posterior surface of the cranium. The abbreviations "AP" and "PA" are common usage both in written and spoken communication. You will understand that the part has moved through 180 degrees, not a 90-degree difference. Between the AP and the PA, we have another position called the lateral.

The term "lateral" indicates a side view of the part. The CR may pass from the lateral to the medial aspect or surface of the part (usual procedure for the upper extremities), from the medial to the lateral surface (usual procedure for the lower extremities), or from one lateral to the other lateral surface (as for the trunk or skull). For lateral projections of the extremities, lateral to medial or medial to lateral describes the entry and exit points of the CR. Lateral projections of the trunk and the skull are designated as right lateral or left lateral, depending upon which side of the part is placed nearest the film. When written on a request slip, all lateral positions of the extremities are usually referred to by the term "lateral" without the clarification of medial-to-lateral or lateral-to-medial. In performing a lateral position of the trunk or skull where only the word "lateral" has been indicated, the specialist should do that lateral position which puts the side (right or left) of the disease or injury nearest the film. Now, we have the makings for right-angle viewing. As we turn through the 360-degree plane, you will notice that there are several combinations possible. We could take an AP with a left lateral. We could take an AP with a right lateral. We could take a PA with a right lateral, or we could do a PA with a left lateral. Each of these four combinations would have given us right-angle viewing. Naturally, we could not exercise all four pairs on the same patient. It boils down to a choice between AP and PA and a choice between left lateral and right lateral. Why do we prefer an AP to a PA on this particular body part when on the next we might prefer the PA to the AP? Naturally, we would try to get the part that is under consideration as close to the film as possible. This is true for the lateral view also.

For each and every patient that comes in, the specialist does not have to reason out which is the best to do. Every clinic will have a routine procedure for each given part. In fact, here at the school, we also require a clinical routine for each part. You will find that these routines closely adhere to the clinic routines.

We have the name of another position that is also very important, an oblique projection. The term oblique (or semilateral) applies to a projection made with the part at an inclined angle to the film or with the CR directed obliquely. In a true oblique position, the part is rotated 45 degrees (half the difference between the AP (or PA) and the lateral). In other words, if I assumed the AP position and turned 45 degrees to the AP and lateral projection, you would notice that I made four facing movements of 90 degrees--that I had accomplished four different oblique positions. Each of these has a name. It is important to remember that the way the central ray enters and exits the part determines the name of the position.

Let us assume again that you are the tube, I am the patient, and the wall behind me is the film surface. In this position, you will notice that the left posterior surface of my body is nearest the film. Hence, we call this a left posterior oblique position. Actually, the ray passes from anterior to posterior on its way to the film. This oblique position is commonly abbreviated "LPO". The anterior surface of the right side is nearer the surface of the film; we are standing in an oblique position. Combining these, we get the name of the position which is right anterior oblique. Remember, we abbreviate this "RAO".

There are several projections of the body, particularly of the skull, that assume the name of the author of the position. This author may have been a doctor, which is true in most cases. Sometimes the name of the author is the technician who originated that position. These came about by the fact that the radiologist was not able to see, by conventional means, the part of the structure demonstrated that he wished to see. A lot of thought and experimentation with dry bone specimens went into the development of these positions. As these were approved on live cases, the radiologist who had perfected these positions would make a public release of what he had found. Many of these form the basis of some of our routine work today. You will hear names like Water's sinus, Bowen-Hirtz skull, Granger's mastoid, Law's mastoid, Jones' elbow, and many, many others. When you say "Laws mastoid" to me, it means particular things. It means that the head was positioned in a precise and exact way. It means that the ray was angled at a specific degree and direction, and that the ray passed through a particular structure of the part on its way to the film. If we use the position exactly as the author used it, then we give the author credit for that position. We call it "Law's mastoid." If we decide to vary the angle of the ray because a particular radiologist wanted the variation, then let us be careful to call it a variation of Law's position.

Terms that will be a part of your life now are basic in positioning the patient. AP and PA (anteroposterior and posteroanterior) are positions of the anatomical part in relation to the central ray as we have discussed. The lateral position we have found to be 90 degrees to the AP or PA position. We find that this position is identified by the side nearest the film. Between the AP or PA and lateral position we have the obliques. How are the obliques of the head and trunk identified? Yes, they are identified by the way the central ray enters and exits the body and by the side nearest the film. These are specific positions of the head and trunk. In more general terms we also have the patient in supine or prone position. By supine we mean the patient lying on his back, whereas for the prone position, the patient is on his stomach. Even more generally, we have the patient in the recumbent position--simply lying down--horizontal.

In the classroom and laboratory, we will be constantly using the above terms as well as abbreviations of terms used daily in the explanation, demonstration, and in the application of radiographic positions.

The term "routine" refers to the necessary radiographic positions or views needed to accomplish right-angle viewing and/or a general survey of the anatomical part to be demonstrated.

"Additional views" are positions or views in addition to the routine for a more thorough visualization of the part and/or specific structures.

"Part-to-film holder reference" (PFR) refers to the specific placement of a palpation point or anatomical part on the film holder to properly demonstrate the part. For example, to demonstrate the lateral view of the hand, the PFR would be: the head of the second metacarpal to the center of the film (holder).

"Central ray-to-part reference" relates to the specific placement of the central ray to an anatomical part or palpation point, thereby projecting that part or point to the center of the film (holder). For example, to properly position the AP cervical spine, the CRPR would be: CR to midpoint of the thyroid cartilage projected to the center of the film (holder). The film holder is adjusted so that the central ray would strike the center of the film (holder).

"Film rundown" refers to the film holder requirements for a procedure (routine or additional views) with reference to the film holder size (8 x 10, 10 x 12, or 14 x 17), the film holder placement in relation to the anatomical part (lengthwise, LW; or crosswise, CW), and whether the use of a grid (B) or nongrid (NB) accessory is necessary. The film rundown for an individual view of a routine will refer to the film rundown of the routine. For example, the routine hand film rundown is: 10 x 12, CW, NB. Thus, the film rundown for the oblique hand is: 10 x 12, CW, NB.

For the ID (Film identification) or "FLASH ID" system, a letter marker "R" or "L" will be placed in the exposing area without being superimposed in the anatomical part being demonstrated. The following applies: for all views of the upper and lower extremities, the letter marker will correspond to the extremity; for the AP, PA, and OBL view of the trunk and skull, the letter marker will correspond to the side it is placed with or the side of demonstration; for the lateral views of the trunk and skull, the letter marker will correspond to the side nearest the film.

The term "central ray" (CR) refers to the angle and direction of the central ray with relation to the film holder or other reference. The central ray is always to the center of the film area to be exposed whether a PFR or CRPR is used. When using a PFR the CR is positioned to strike the center of the film being exposed. For CRPR's, the film is adjusted so that the CR will strike the center of the film to be exposed.

The "conefield" gives reference to the film area being exposed by the primary X-ray beam. Film coverage in the conefield is any area being exposed whether it be 1/4, 1/3, 1/2, or the whole film holder; thus, the conefield requirements for the PA hand would be the film coverage. In all other conefields, the size of the diameter of the field will be specified. For example, the conefield requirements for the open-mouth cervical is specified as six inches.

"Breathing technique" refers to required instructions given to the patient prior to making the exposure. Following the exposure, it should always be remembered that the patient be instructed to breathe normally. The types of breathing instructions are as follows: for "suspended respiration," the patient is instructed to stop breathing at any time; for "suspended inspiration," the patient is instructed to take in a deep breath and hold in the breath during the exposure; for "suspended expiration," the patient is instructed to take in a breath then let out his breath holding out his breath during the exposure.

"Demonstrates" refers to the primary and surrounding anatomical structures that are demonstrated on the radiograph.

"Alignment" is the necessary position of certain anatomical structures and/or anatomical planes in relationship to the film, other anatomical planes, etc., to properly demonstrate the part. For example, to properly demonstrate the AP elbow, the epicondyles of the humerus must be parallel to the film.

"Focal film distance" (FFD) is the measured distance in inches between the tube focal spot and the film holder. The following applies:

for table-top procedures, the FFD is measured through the film holder to the table top; for Bucky procedures, the FFD is measured to the table top at a measurement allowing two inches to the Bucky tray (i.e., if a 40-inch FFD is required for a Bucky technique, a measured distance of 38 inches to the table top is set, thus leaving two inches from the table top to the Bucky tray where the film holder is placed, resulting in a total distance of 40 inches FFD).

"Cassette" refers to the film holder. In X-ray, the cassette is a special type of holder. Generally, the top of the cassette is black (bakelite) framed by a metal border. In the use of PFR's, the metal border is included in the measurement. Conefields also include the exposing metal borders. Cassettes with bakelite tops of other colors (generally orange or red) are grid cassettes where the grid is included in the bakelite. These should be compensated for in technique as they are for Bucky procedures.

The Optimum KvP Technic Chart--100 mA, 100 kVp--is for use with the full-wave rectified 100 kVp, 100 mA machine (stationary anode) only. Film holders on this chart are cassettes with high-speed screens. The Bucky used is 6:1 where indicated by "B" in the last column. This chart is based on full-wave rectification. Use the chart to adjust for centimeter measurements above or below the centimeter (cm) range shown.

Please refer to your sample factor chart since, at this time, we would like to review some of the things that you learned when we discussed this chart previously. This is the exact chart that you will be using for your applied laboratory exercises. It is very important that we know how to interpret this chart. We do not commit this chart to memory. We have frequent use of the chart which may become a part of our memory, but we do not actually try to memorize the facts contained herein. We must be sure, however, that we are able to interpret the things that are written hereon. Notice the heading of the chart. It says that this is an Optimum Kilovoltage Technic Chart which is adapted to the 50-100 mA unit. Read the preface with me. This chart is based on the use of high-speed screen and a 6:1 ratio Bucky as needed. When necessary, change the basic time of exposure(s) to fit the "above" or "below" range centimeter thickness measurements as indicated.

Follow the headings across as we tell them to you. The parts are listed here in the order that they are taught. Under each part, you will find a listing of all positions that are taught concerning that part. Under "Film," there are three items of information. These are: (1) the amount, (2) size, and (3) how the film is turned. The next column is labeled "cm." It is the most important column on the chart. You will notice next to each part that a centimeter range is listed for that part. For instance, next to the "HAND, Lateral" we notice the figures "7-10" are written. What does that mean? Every hand that measures 7, 8, 9, or 10 centimeters in the lateral projection will receive the same basic factors.

873

If a hand measures less than 7 centimeters or more than 10 centimeters laterally, we must consult our chart to see what changes of the time of exposure should be made.

It is important that you know how to measure a part. What is the thing that I have in my hand? Stick, did you say? Well, you could call it a stick. This stick is a caliper. This caliper is the device that is used to measure the part. I will demonstrate the correct method of measuring with the caliper. The rule for correct measurement of the part has few exceptions. That rule is, measure that part through the plane that the CR transverses, lightly touching the skin at points of entry and exit of the ray. Measure in the same plane that the CR passes through, lightly touching the skin at points of entry and exit of the ray. When measuring the skull, do not stop at the hair--lightly touching from skin to skin. As I start to read, I see that there are two places that I can read. One says 19 something or other, and the other says seven and a half. You see, there are two scales; and at the top of the caliper, you notice that one says inches and the other says centimeters. As previously noted, we use centimeters thickness for our basis of exposure values. This 19 centimeters that we recorded happens to sit in the middle of our cm range for that part. That means that we would use the rest of the chart as is.

Measure the skull in a lateral position. In this particular direction, I have a measurement of 15 centimeters. Surely we could assume that the direction that measured 19 centimeters would require more radiation than the direction that required 15 centimeters. That is always true of the same given part. The greater cm thickness of a particular part will require greater factors. For the exact factors to use for a given measurement of a part, we would read it off our chart. I will demonstrate the improper method of measuring by squeezing the calipers tight against the head in the lateral position in order to get a smaller reading. Remember, "...lightly touching from skin to skin in the same plane that the CR passes through the part."

The next column on your factor chart is headed "kV." That stands for kilovoltage of which you are already aware. The next column is "Focal Spot," utilize small or large. Next, set the mA for the listing that you see here that agrees with the prereading card that you have on each machine. The next column, "s," indicates the time of exposure. Simply set the time to the time indicated on the chart. The same applies for the next, "FFD." The next column, "B," indicates "Bucky." When the Bucky is to be used, you will notice a "B" in the column. When the Bucky is not to be used, you notice no listing at all.

Remember, everything in this chart that is called for is already compensated for. If the Bucky is called for, the Bucky is compensated for. If you have to make a change because of the condition of the patient, then you must change the chart too. CR (central ray) lights are used on some machines.

877

You now have the format of the positioning phase and the terminology we use in the explanation, demonstration, and the application of radiographic positions. Do not forget that we came here to learn to serve the sick. Our best efforts here will assure that his clinical needs will be met.

875

SFC JIMMIE BINKLEY

ACADEMY OF HEALTH SCIENCES, US ARMY *LP 38-520-028
DIVISION OF MEDICINE & SURGERY 076
X-RAY BRANCH

Film Identification: Captioning (2 hours)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES: TM 8-280, pp 10-5.

STUDY ASSIGNMENT: After class study GR 38-520-027-1 and review TM 8-280, pp 10-5.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280, GR 38-520-027-1.

TOOLS, EQUIPMENT, AND MATERIALS: SF 519A, Radiographic Report; BAMC Form 1-703, X-Ray Flash Card issued before class and GR 38-520-027-1 issued at beginning of third week.

PERSONNEL: One instructor (MOS 91P2H or 91P4H).

INSTRUCTIONAL AIDS: Chalk, Chalkboard, and eraser; PA system with lapel mike; roentgenographs, film marking set, flash identification printer, magnetic "R" and "L" (approx. 2 1/2 in height) (See Annexes A and B).

TROOP REQUIREMENTS: None.

TRANSPORTATION REQUIREMENTS: None.

TYPE OF INSTRUCTION: Lecture (DN).

I. INTRODUCTION (3 min)

A. Opening Statement: How would you feel if you caused a patient to have an amputation of the wrong extremity? Did you know that because of even the slightest film identification error, a perfectly good radiograph would have to be repeated. This, of course, would also subject your patient to unnecessary radiation exposure. You have a tremendous responsibility as an X-ray specialist--not only to your patient, but to your radiologist and yourself. It is your personal responsibility to ensure that all radiographs are properly identified before processing.

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*This lesson plan supersedes LP 38-520-028, 064

876

B. Objectives

1. State the 9 items on the X-ray request slip (SF 519A) that must be filled out before it can be processed by the receptionist.

2. List two primary methods of transmitting permanent identification to radiographs.

3. State the four items of patient information required to properly identify a radiograph.

4. Given a description of a position, determine the proper letter marker to be used.

5. Given radiographs of the trunk and skull, determine, by the letter marker, the position of the part.

C. Class Procedure and Lesson Tie-in

None

II. EXPLANATION (67 min)

A. Radiographic Report (SF 519A)

NOTE: Explain the two functions of this form--radiographic request, radiographic report.

1. Request

NOTE: Refer students to SF 519A and briefly explain the following:

a. Name

b. Rank

c. SSAN

d. Unit

e. Ward or clinic

f. Examination requested

g. Pertinent clinical history

NOTE: Explain, through use of examples, how this is primarily for the use of the radiologist but may assist the technician also.

h. Date of request

i. Requested by

NOTE: Request must be signed by a MEDICAL CORPS officer.

NOTE: Explain that the age of patient should be included on SF 519A.

2. Report

a. Radiologist's findings

b. Radiologist's signature

c. Date of report

QUESTION: Who's signature is required on the SF 519A before it can be processed?

ANSWER: Medical Corps officer's.

QUESTION: What area of the SF 519A is used by the radiologist for additional information about the patient's condition?

ANSWER: Pertinent clinical history.

B. Film Identification

1. Methods of transmission to film

a. X-ray exposure

b. Light

NOTE: Have students look at flash cards as you briefly demonstrate the use of the I.D. flasher.

c. Written

2. Patient information required on film caption

a. Name

b. Age

c. SSAN

d. Date

NOTE: Date on film caption is the date the film was taken.

3. Rules for determining proper letter marker

NOTE: Letter marker must be placed on film by technician prior to making the exposure.

NOTE: Use magnetic letter markers to explain the following rules:

a. Extremities--letter marker corresponds with the extremity, i.e., right hand = "R"

b. Trunk and skull

(1) AP, PA, and OBL--letter marker corresponds with the side of the body it is placed with.

(2) LATERALS--letter marker corresponds with the side nearest the film.

c. Conefields

(1) Extremities--the rules above apply.

(2) Skull and trunk--the rules above apply

NOTE: Explain, through use of examples, the application of this rule, i.e., optic foramen, mastoid, petrous, etc.

QUESTION: What does the letter marker indicate on lateral views of the trunk and skull?

ANSWER: The side nearest the film.

III. FILM DISCUSSION (15 min)

A. Classroom Arrangement

1. View boxes centered on podium

2. Students seated in semi-circle

NOTE: Use radiographs to demonstrate positive and negative examples of material covered.

B. Procedure for Conducting Film Discussion

1. Show radiograph

2. Determine if properly identified

3. Determine by letter marker the position of the part

C. Questions From Students

NOTE: Make study assignments: After class, study GR 38-520-027-1 and TM 8-280, pp 10-5.

IV. SUMMARY (5 Min)

A. Review of Main Points

1. Radiographic report

2. Information required on film caption

3. Rules for determining letter marker

B. Closing Statement: Your job as an X-ray specialist should be taken seriously. As we have mentioned, it is your personal responsibility to see that all radiographs are identified properly.

880

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*LP 38-520-029
076

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

Exposure Room Orientation (1 Hour)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES: None

STUDY ASSIGNMENT: None

STUDENT UNIFORM AND EQUIPMENT: N/A

TOOLS, EQUIPMENT, AND MATERIALS: None

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Chalkboard, chalk, eraser, and simulated x-ray clinical laboratory setup.

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

I. INTRODUCTION (5 Min)

A. Opening Statement: To be an X-Ray Specialist, you will have to work at it; x-ray is a performance skill. When you finish this course, you will be sent to an X-Ray Clinic, where you will have all the necessary equipment, and patients will be arriving. You will be expected to produce satisfactory radiographs. This course gives classes presenting all the required steps to produce diagnostic radiographs. This is not enough! To make radiographic procedures a part of you, to put them at your finger-tips, requires practice under actual conditions. This is supplied in the laboratory phase of your instruction. We have a fully equipped X-Ray Laboratory available to develop your skills. This hour we will tell you how this Lab phase of instruction is conducted and tour the X-Ray Laboratory.

B. Objectives

1. List the normal sequence of activities in the Laboratory phase of instruction.

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*This lesson plan supersedes LP 38-520-029, 044.

884

881

LP 38-520-029
076

2. Describe expected conduct during the laboratory phase.

3. Locate essential areas of activity in the x-ray laboratory.

C. Class Procedures and Lesson Tie-in--None.

II. DEMONSTRATION (35 Min)

A. Organization of Typical Laboratory

1. Initial period
   - a. Arrival time
   - b. Authorized absences
     - (1) Notify group leader
     - (2) Sign out
   - c. Film badge roster
   - d. Machine assignment roster
   - e. Instructions and grade sheets
   - f. Assignment of student roles and machine operation

2. Types of activities
   - a. Ungraded practical exercises
   - b. Crucial objectives
     - (1) 45 minute time limit per 5 positions
     - (2) "S" or "U" grade

3. Termination period
   - a. Instructor's critique
   - b. Complete grade sheets
   - c. Preventive maintenance
   - d. Replace film badges
   - e. Dismissal

885

QUESTION: What is the prime consideration when role-playing as patient?

ANSWER: Do not reveal any information concerning the position to the student specialist.

B. Behavior and Conduct in Laboratory

   1. Food, beverages, smoking banned
   2. Personal hygiene
   3. Personal appearance
      a. Uniform
      b. Shoes
      c. Haircuts
   4. Unsupervised activities banned

C. Tour of Laboratory Area

   1. Automatic processor
   2. Storage bins
   3. Film badge cabinet
   4. Film badge
   5. Machine assignment roster
   6. Map of machine locations
   7. Typical exposure room
   8. Manual dark room
   9. Film transfer cabinet

QUESTION: What two types of activity will be found in the lab?

ANSWER: Ungraded practical exercises, and crucial objectives.

D. Questions From Students

III. SUMMARY (5 Min)

A. Review of Main Points

883

1. Normal lab activities
2. Expected lab behavior and conduct
3. Location of lab areas

B. Closing Statement: As you leave this laboratory, think upon this: This is where you will learn those basic skills required to function in the x-ray world. Without those skills, all the classroom and textbook knowledge you acquire is useless. Here you must perform, and performance is what counts!

SFC JIMMIE BINKLEY
*IM 38-520-029
076

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

Instructor's Manuscript For "Exposure Room Orientation"

To be an X-Ray Specialist, you will have to work at it! X-Ray is a performance skill. When you finish this course, you will be sent to an X-Ray Clinic where you will have all the needed equipment, and patients will be arriving. You will be expected to produce satisfactory radiographs. This course gives classes presenting all the required steps needed to produce diagnostic radiographs. This is not enough! To make radiographic procedures part of you, to put them at your finger-tips, requires practice under real conditions. This is supplied in the laboratory phase of your instruction. We have a fully equipped x-ray laboratory available to develop your skills. This hour we will tell you how this lab phase of instruction is conducted and tour the X-Ray Laboratory.

What will you be able to do at the end of this hour? What will we expect of you? First, list the sequence of activities in the laboratory phase of instruction. Second, describe the expected conduct during the laboratory phase. Finally, locate essential areas of activity in the x-ray laboratory.

A normal day during positioning instruction is composed of the classroom period and the laboratory period. During the classroom period, the anatomy of the positions will be reviewed, and other essential information will be presented. The positions will be thoroughly demonstrated, and most questions will be answered. This is fine, but is it enough? No - to master these positions, you yourself need to perform them. This is accomplished during the practical exercises in the laboratory.

Arrive at the laboratory at least five minutes before starting time. This will allow time for you to store your personal items, pick up your film badge, and find your machine assignment on the assignment roster. Don't forget your film badge! This is an essential item in the laboratory. This little film badge (instructor holds up his film badge) is for your protection. If there should be some defect in the radiation protection arrangements, this badge will detect it. Pick up the film badge at the beginning of the lab session, and replace it in the badge cabinet when you are dismissed. I will show you the location of the cabinet later.

After clipping on your film badge, find out your machine assignment for the day. A machine assignment roster is posted in the laboratory area weekly. The machines are numbered one through eleven - a map located below the assignment roster will help you find your machine. Two (and occasionally three) students are assigned to each machine.

Before you go to your assigned machine, the Laboratory Supervisor and your Group Leader will give you any special instructions for the day, and

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*This instructor's manuscript supersedes IM 38-520-029, 044.

will give you your grade sheet. We will explain this grade sheet during the next teaching day. Take your grade sheet and go to your machine. An instructor will be there to direct your activities. One of the students assigned to each machine will be designated to play the patient's role, and the other will serve as the student x-ray specialist.

A word about these "roles:" If you are the student patient, play the role of the patient -- do not give any information to the specialist, especially during testing! Deliberate or unintended clues given to the specialist will be considered cheating. Don't compromise your position in the Academy by slipping your "partner" information.

Normally each of you will be allotted an equal portion of time serving as the student specialist. What will you be doing during your time at the controls? We have two types of activities in the laboratory: Ungraded practical exercises and crucial objective testing. When you are fortunate enough to have ungraded practice, take full advantage of it. It grants you a "trial run" without the pressure of the testing situation.

I imagine that you have heard of crucial objective testing already! It plays an important part in our course; it is our way of determining if you are ready to function in a working clinic. Crucial objective scores do not effect your numerical grade; however, you are required to satisfactorily complete a certain number of crucial objective positions each week. In the third and sixth weeks, the minimum requirement is seventy percent of the number of positions performed for crucial grading. In the seventh and ninth weeks, eighty percent is required to be satisfactory. During the next two teaching days, crucial objective testing will be described in detail.

At the conclusion of each laboratory period, we tie up all the loose ends. A thorough cleaning of the entire lab area is conducted, and all grade sheets are completed by instructors and students. During the completion of the grade sheets, your instructor will give you a thorough critique of your day's work. He will point out your weak areas, and comment on what you did correctly. Do not leave the lab until your instructor dismisses you! Once you are dismissed, replace your film badge in the film badge cabinet. Your film badge should never leave the laboratory area.

Our x-ray laboratory is both a teaching area, and a similated working x-ray clinic. Because of this, certain requirements of conduct and behavior are insisted upon by the Academy. Our lab is close to the snack bar, but all food, drink, and smoking are prohibited. The laboratory is not a social center -- playful activities will be confined to the official break areas. Normally, a 15 minute break is given each hour. Save your boisterousness for these free periods. The lab is a working area -- not for fun and games.

To repeat, the laboratory is a working area. X-ray machines are not toys, nor are they to be tinkered with in the absence of the instructor. We require you to stay out of the exposure rooms unless an instructor is present. We have had students charged for damage to x-ray machines. Don't let this happen to you!

Now to touch on a delicate matter, a matter which will not pertain to the majority of young adults. However, we do find an unfortunate few who have not learned to maintain daily bathing habits. Personal hygiene is extremely important in all medical work. What would be your reaction if you were cared for by an x-ray specialist wearing unkempt, dirty whites, whose body odor was evident? Would this cause you to feel confident in the quality of care that you were receiving? Bathe daily, and use a deodorant. Keep your fingernails clean, and your hair trimmed. Shined shoes also make a good appearance.

Now we will tour the x-ray laboratory. This is the entrance. Adjacent to the entrance, you will notice the Academy Snack Bar. This is a very handy location for "breaks," but please remember not to bring food, drink, or smokes into the lab area. As we enter the lab, we walk straight ahead and then turn left, passing through another set of doors. The first dozen or so rooms that we encounter comprise the Special Procqdures area of the laboratory. You will become very familiar with this area in nine more weeks. This is the Automatic Processing Room. Here we have an automatic processor that will develop, fix, wash, and dry an x-ray film in 90 seconds.

Now we near areas which are of direct concern to us. These are the storage bins for personal items -- coats, hats, books, etc. We strongly advise the young ladies to carry their purses with them. Here we find the Film Badge Cabinet. A film badge roster is located on the inside of the cabinet door. The number by your name indicates the film badge that you will wear. Always pick up your badge before beginning work, and replace the badge before leaving the laboratory. A little further down the hall, on the end of the storage bins, we find the machine number assigned to you for that day. This small map located below the assignment roster will help you locate your machine.

This is a typical positioning exposure room. Our x-ray machine is the 100/90 Picker Field Unit. This is the standard Army field unit, and, with minor adaptations, the standard Army portable x-ray unit. During our next teaching day, you will become familiar with this machine, and all equipment in this room.

At the extreme end of the laboratory hallway we find the manual darkroom. In the eighth week of your instruction, you will learn the intricacies of manual processing. There is one aspect of darkroom operation that I want to show you now: The use of the film transfer cabinet, commonly called the "Pass Box." We see two doors -- one marked "Exposed," and the other marked

887

"Unexposed." After an exposure is taken, the film cassette is placed in the left side of the Pass Box, in the section marked "Exposed." Place the cassette into the "Exposed" side, bakelite to the left, tab end first. This is the general rule for the standard, full-size pass box. However, here we have a small pass box, that will not accommodate our largest cassette, the 14 x 17 inch size, when it is placed with the tab-end first. All 14 x 17 cassettes must be placed tab end down in this box.

As you leave this laboratory, think upon this: This is where you will learn those basic skills required to function in the x-ray world. Without those skills, all the classroom and textbook knowledge you acquire is useless. Here you must perform, and performance is what counts!

NOTE: PAGES 888-889 HAVE BEEN DELETED; HOWEVER ALL MATERIAL HAS BEEN INCLUDED.

890

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*LP 38-520-030
066

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

Order of Procedure: Demonstration (1 Hour)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES:

TM 8-280, pp 10-7

STUDY ASSIGNMENT: After class study TM 8-280, pp 10-7 and GR 38-520-027-1.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280, GR 38-520-027-1

TOOLS, EQUIPMENT, AND MATERIALS: None

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Chalkboard, chalk and eraser; PA system with lapel mike; order of procedure guide; request slip (SF-519a); fully articulated skeleton; pointer.

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

I. INTRODUCTION (5 Min)

A. Opening Statement: In pursuit of becoming x-ray technologists, several facts have already been presented. Given positioning instructions you could probably perform some examinations in a clinic but you would encounter difficulty in correlating all the facts necessary to perform these examinations in an orderly sequence. There is a logical sequence of events that will provide you with all the necessary steps in producing a diagnostic radiograph. While positioning your fellow students in the laboratory you will be graded on the proper use of these sequential steps, "Order of Procedure."

B. Objectives

1. Determine the X-ray technologist's role in performing a radiographic procedure

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*This lesson plan supersedes LP 38-520-030, 034.

[illegible]. Identify in sequence the order of procedure required for radiographic positioning

3. After practice apply the order of procedure in proper sequence while positioning the patient to produce diagnostic radiographs

C. Class Procedure and Lesson Tie-in

None.

II. DEMONSTRATION (35 Min)

A. Orientation to Clinical Procedure

1. X-ray technologist patient relationship

2. Work assignments

B. Explanation Order of Procedure

1. Purpose

2. Grouping of facts

NOTE: Refer students to GR 38-520-027-1.

C. Demonstrate Order of Procedure

NOTE: Instructor use articulated skeleton on x-ray table as patient for demonstration.

1. Control Panel

a. Measure part

b. Set technique factors (mA, S, and kVp)

2. Table Factors

a. FRD and Letter Marker

NOTE: Put letter marker on film at this time.

b. Set angle of tube

c. Set FFD

3. Position Patient

a. PFR/CRPR

b. Alignment

NOTE: At times it may be more advantageous to do alignment prior to doing PFR/CRPR.

c. Align CR to center of film being exposed

d. Set proper conefield

NOTE: Check FFD, LETTER MARKER, and CONEFIELD.

4. Exposure

a. Verify factors

b. Give instructions to patient

c. Make exposure

QUESTION: Why must you verify factor settings?

ANSWER: As a final check to ensure all the technical elements are correct to produce a diagnostic radiograph.

D. Questions From Students

NOTE: Made study assignments: after class study GR 38-520-027-1 and TM 8-280, pp 10-7.

III. SUMMARY

A. Review of Main Points

1. Orientation to clinical procedure

2. Order of procedure

B. Closing Statement: By putting into practice the order of procedure, we as x-ray technologists can perform our technical skills in an effective and professional manner.

893

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*IM 38-520-030
066

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

Order of Procedure Demonstration

In pursuit of becoming x-ray technologists several facts have already been presented. Given positioning instructions you could probably perform some examinations in a clinic but you would encounter difficulty in correlating all the facts necessary to perform these examinations in an orderly sequence. There is a logical sequence of events that will provide you with all the necessary steps in producing a diagnostic radiograph. While positioning your fellow students in the laboratory you will be graded on the proper use of these sequential steps, "Order of Procedure."

As an x-ray technologist you will often be the only person on the professional staff the patient comes in contact with. You will be preparing the patient for his or her examination, giving the patient instructions for pre-examination medications if indicated, positioning the patient for the exam, operating all equipment, developing films and critiquing from a technical aspect, yours or your co-workers films.

The x-ray technologist-patient relationship is one of great importance. Realizing the patient is in pain, in unfamiliar surroundings and possibly has never seen an x-ray clinic before, all this adds to the anxiety of the patient's emotional state. Taking the time to introduce yourself, and in a professional manner explaining the examination you will be doing, will help the patient be more at ease. He or she will be more cooperative and this attitude will greatly enhance the examination. Having to work with an uncooperative patient not only makes the examination unpleasant for all concerned but also increases the odds of making a mistake.

There will be times when you as x-ray technologists will work by yourself in a routine diagnostic room performing the examinations by yourself. At other times you may work as part of a team of technologists in special studies performing arteriograms, venograms and other special exams. You may be assigned to assist the Radiologist with fluoroscopic examinations or the X-Ray Technologist working in the Emergency Room of the hospital. Regardless of your work assignment, there are certain steps that are always followed while performing all examinations. By correlating these steps and performing them correctly in proper sequence, you will be able to smoothly and effectively perform all required examinations.

The order of procedure is just what its title implies. A logical sequence of steps, which when followed, not only eliminates the possibility of error, saves time and wasted motion but allows you to act in a positive and professional manner.

There are four main categories or divisions of the order of procedure. Eache category contains steps to be followed which are listed in a logical sequence. When the first group of steps are completed the technologist

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*This Instructor Manuscript supercedes IM 380-520-03, 034.

proceeds to the next group of steps and so forth until all the steps have been performed.

In X-Ray departments you will be given a written or an oral request stating the patient's name and examination the doctor would like the technologist to perform. This request form is very useful as it will aid the technologist in determining the patient's physical condition and any special care to be used when positioning the patient for his/her examination.

At this time you should call the patient from the waiting room using his/her correct title (rank for military or Mr., Mrs., or Miss, for all patients as applicable). When the patient responds, briefly introduce yourself and ask the patient to accompany you to the exposure room.

When you reach your exposure room have the patient sit on a stool alongside of the X-Ray table or sit/lie on the table. If you must make up an I.D. strip now is the time to do so. You should also ensure that all foreign objects have been removed from the area of the patient's body that is to be x-rayed.

Let us go through the order of procedure as it is shown in GR 38-520-027-1. The first division or main category is the control panel. In this category we have two general steps; first you measure the part to be examined using radiographic calipers and next, using the measurement you have obtained, refer to the radiographic technique chart and set your machine factors on the control panel of the X-Ray machine (kVp, mA, time) to the suggested technique of the part to be radiographed.

You are now ready to begin the second step of your order of procedure which is table factors. First obtain the correct size cassette and affix the correct letter marker to the cassette and place the cassette on the radiographic table or in the bucky tray. Now set the angulation of the tube (HP-VP-or an angled ray) as the position dictates. After setting the angle, set the F.F.D.

Now you are ready for step three, which is position the patient. First set the part to film reference or the central ray to part reference. Now align the part to the film. At times it may be more advantageous to set the alignment prior to setting the PFR/CRPR. Now immobilize the part at this time using radiographic positioning sponges or sandbags. At this time grasp the tube, not the collimater device, align the central ray to the center of the film being exposed. After aligning the C.R., set the proper conefield by collimating the lighted beam of the C.R.

Before you move on to the next step it would be advantageous to recheck the F.F.D., Letter Marker, and the conefield for accuracy.

Now you are ready for the third and final category of your order of procedure, the exposure. Moving back to the control panel, verify the technical factors to insure you have set the porper technique. Now give instructions to your patient such as, hold your breath, don't move, and make the exposure by depressing the exposure button. The exposure is then made and the patient is instructed to breathe normally and relax. After completion of the routine, assist the patient from the x-ray table, place the films in the exposed side of the passbox and proceed with the next examination.

By putting into practice this order of procedure, we as x-ray technologists can perform our technical skills in an effective and professional manner.

896

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066

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

Positioning of Upper Extremity: Hand (1 hour)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES:

TM 8-280, pp 10-8 thru 10-10.
Merrill, Vinita. Atlas of Roentgenographic Positions. 3d ed., Vol. I. St. Louis: C.V. Mosby Company, 1967, pp 32-35.

STUDY ASSIGNMENT: After class study GR 38-520-027-1 and TM 8-280, pp 10-8.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 and GR 38-520-027-1

TOOLS, EQUIPMENT, AND MATERIALS: GR 38-520-027-1 issued at beginning of third week

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Chalkboard, chalk, and eraser; PA system with lapel mike; Radiographs of the hand, pointer, x-ray illuminator (see Annexes A through C)

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

I. INTRODUCTION (2 min)

A. Opening Statement: To correlate basic positioning to your classes in anatomy, we find that the first anatomical structures you covered were bones of the hand. Your first radiographic procedure will be to properly position the hand.

B. Objectives

1. Identify by name the position and anatomical structures demonstrated of the routine and additional view of the hand.

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*This lesson plan supersedes LP 38-520-031, 123.

897

2. State the correct routine, PFR/DRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization, film identification and captioning necessary to demonstrate the position(s) of the routine and additional view of the hand.

3. Given a request slip and a simulated patient in the x-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiograph(s) of the routine and additional view of the hand.

C. Class Procedure and Lesson Tie-in

1. Students will gather around the x-ray table during the demonstration.

2. Students will be demonstrating these positions in their laboratory practical exercise on crucial objectives

II. DEMONSTRATION (40 min)

A. Anatomical Structures Demonstrated -- Hand

NOTE: Place radiograph on viewbox and point out the following anatomical structures.

1. Metacarpals (five)
    a. Base
    b. Head
2. Phalanges (fourteen)

QUESTION: Where are the heads of the metacarpals located?

ANSWER: Distal.

B. Position

NOTE: Refer to Annexes A through C for explanation of positions and have the students fill in their GR's.

1. Posterior-anterior (routine)
2. Oblique (routine)

NOTE: Review order of procedure in GR 38-520-027-1.

QUESTION: What is the part-to-film reference for the PA view?

ANSWER: The head of the third metacarpal is placed to the center of the film.

NOTE: Explain purpose and technique of leading off.

NOTE: Bennett's fracture demonstrated with this routine and additional view.

3. View Lateral (Additional)

QUESTION: What are the two purposes for taking the lateral view of the hand?

ANSWER: To give right-angle visualization for foreign body localization and to show anterior or posterior displacement of the metacarpals.

C. Demonstrate positions using information in Annexes A through C.

NOTE: Positions will be demonstrated by the instructor using a student from the class as a patient and refer students to the order of procedure.

D. Questions From Students

NOTE: Make study assignment: After class study GR 38-520-027 and TM 8-280, pp 10-8 thru 10-10.

III. SUMMARY (3 min)

A. Review of Main Points

1. Anatomical structures
2. Positions
3. Demonstration

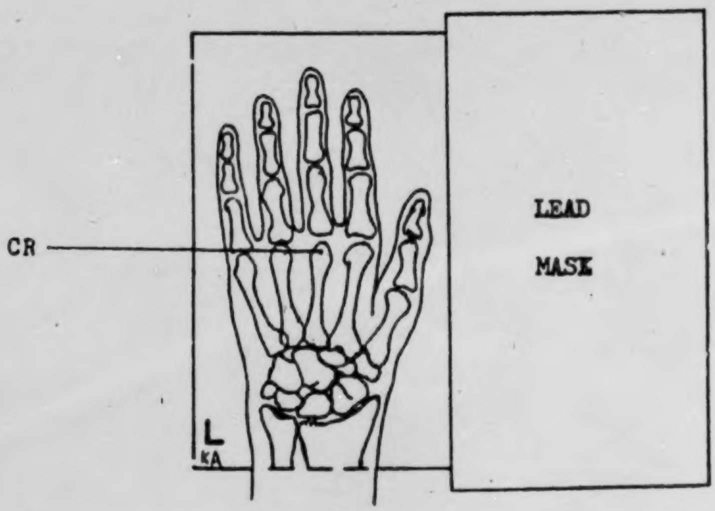
B. Closing Statement: The routine hand is a simple exam to perform, but as with anything, the best techniques should be used to give the radiologist a consistently diagnostic film.

ANNEX A
INSTRUCTIONAL AIDS

Hand

Routine: PA and Oblique

Additional: Lateral



Hand Position PA

PFR: Head of the 3rd metacarpal to center of film

Film Rundown: 1 10 x 12 CW NB CR: VP Cone: FEC

Alignment: Palmar surface flat on film; fingers separated (part centered).

Demonstrates: Digits, metacarpals and carpals.

Notes: FFD: 40" ID: Above part reading down.

Immobilization: Place sandbags against forearm. Remove all artifacts (rings, watches, etc.).

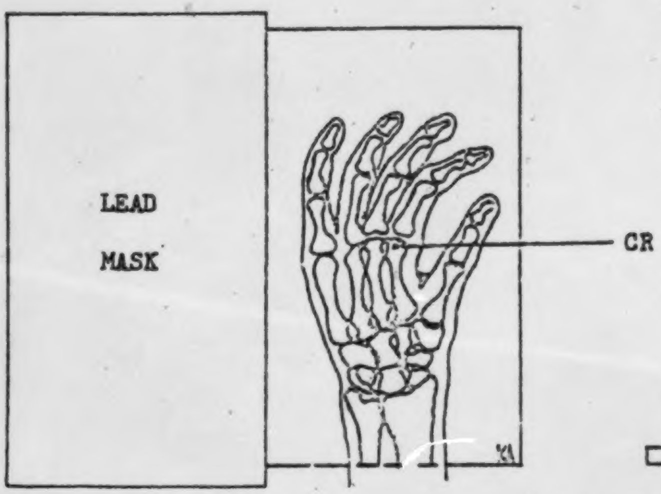
TM8-280 pp. 10-8 Figure 10-3

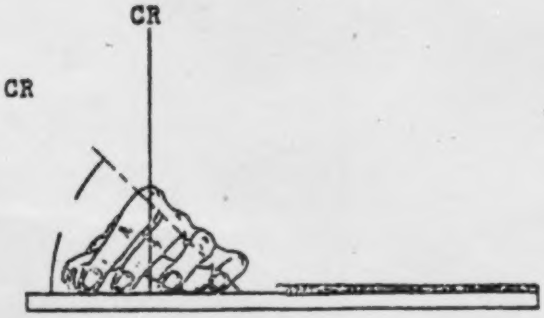
ANNEX B
INSTRUCTIONAL AIDS

Hand

Routine: PA and Oblique

Additional: Lateral





Hand Position Oblique

PFR: Head of 2nd metacarpal to center of film

Film Rundown: 1 10x12 CW NB CR: VP Cone: FFC

Alignment: Part centered: plane through heads of metacarpals forms a 45° angle to film.

Demonstrates: Digits, metacarpals and carpals

Notes: FFD: 40" ID: Above part reading down.

Immobilization: Place snadbags against forearm. Remove all artifacts (rings, watches, etc.).

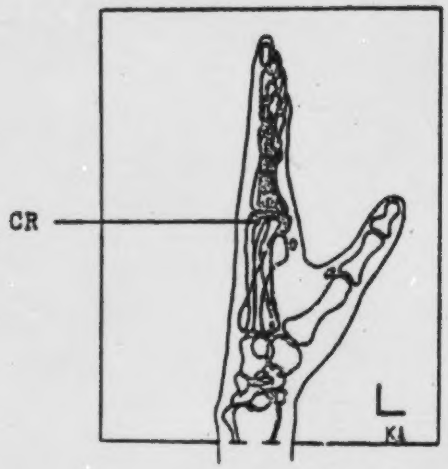
TM 8-280 pp. 10-9 Figure 10-4

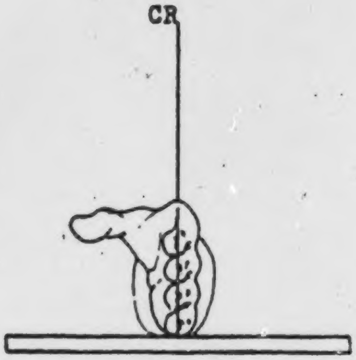
ANNEX C
INSTRUCTIONAL AIDS

Hand

Routine: PA and Oblique

Additional: Lateral





Hand Position Lateral

PFR: Head of 2nd metacarpal to center of film

Film Rundown: 1 8 x 10 LW NB CR: VP Cone: FFC

Alignment: Part centered with hand vertical and fingers extended.

Demonstrates: Primarily: Foreign body localization. Secondarily: Anterior or posterior displacement of metacarpals.

Notes: FFD, 40" ID: Either lateral border.

Immobilization: Place sandbags against forearm, and radiolucent material under thumb.

1) Bennetts' Fracture: A longitudinal fracture of the 1st metacarpal (thumb).

2) Lateral hand position demonstrates thumb in a PA position.

TM 8-280 pp. 10-10 Figure 10-5

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ACADEMY OF HEALTH SCIENCES, US ARMY *LP 38-520-032
DIVISION OF MEDICINE & SURGERY 076
X-RAY BRANCH

Positioning of Upper Extremity: Wrist (1 hour)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES:

TM 8-280, pp 10-12 thru 10-14
Merrill, Vinita. Atlas of Roentgenographic Positions. 3d ed. Vol I St Louis: C.V. Mosby Company, 1967, pp 40-44.

STUDY ASSIGNMENT: After class study GR 38-520-027-1 and TM 8-280, pp 10-12 thru 10-14

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 and GR 38-520-027-1

TOOLS, EQUIPMENT AND MATERIALS: GR 38-520-027-1 issued at beginning of third week

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Chalk, chalkboard, and eraser; PA system with lapel mike; Radiographs of the wrist, pointer, and radiographic illuminators (see Annexes A thru D)

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

I. INTRODUCTION (2 min)

A. Opening Statement: The wrist is a condyloid joint with many articulating surfaces. This fact makes it necessary for us to supplement right-angle viewing by increasing our routine to four views.

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*This lesson plan supersedes LP 38-520-032, 113

903

LP 38-520-032
076

B. Objectives

1. Identify by name the position and anatomical structures demonstrated of the routine wrist.

2. State the correct routine, PFR. CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization, film identification and captioning necessary to demonstrate the position(s) of the routine wrist.

3. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiograph(s) of the routine wrist.

C. Class Procedure and Lesson Tie-in

1. Students will gather around the X-ray table during the demonstration.

2. Students will be demonstrating these positions in their laboratory practical exercise on crucial objectives.

II. EXPLANATION/DEMONSTRATION (40 min)

A. Anatomical Structures Demonstrated - Wrist

NOTE: Place radiograph on the viewbox and point out the following anatomical structures.

1. Distal forearm

   a. Radius

   b. Ulna

2. Carpal bones

   a. Proximal row (lateral to medial)

      (1) Navicular (scaphoid)

      (2) Lunate (semilunar)

      (3) Triangular (triquestral)

      (4) Pisiform

b. Distal row (lateral to medial)

(1) Greater multiangular (trapezium)

(2) Lesser multiangular (trapizoid)

(3) Capitate (os magnum)

(4) Hamate (unciform)

3. Metacarpals

QUESTION: Where is the navicular bone located?

ANSWER: It is the most lateral carpal bone in the proximal row.

NOTE: Stress navicular as common site of fracture and that a good film is needed to see the fracture.

B. Positions

NOTE: Refer to Annexes A through D for explanation of positions and have the students fill in their GR's.

1. PA (routine)

2. PA w/ulnar flexion (routine)

QUESTION: Why do we have ulnar flexion in the PA view?

ANSWER: To better demonstrate the navicular.

3. Oblique (routine)

4. Lateral (routine)

QUESTION: What action is required to insure that the styloids are superimposed?

ANSWER: The styloids must be supinate 5° and elbow flexed 90°.

C. Demonstrate Positions Using Information in Annexes A through D.

NOTE: Position will be demonstrated by the instructor using a student from the class as a patient and refer students to the order of procedure.

D. Questions from students

NOTE: Make study assignments: After class study GR 38-520-027-1 and TM 8-280, pp 10-12 thru 10-14.

III. SUMMARY (3 min)

A. Review of main points

1. Anatomical Structures

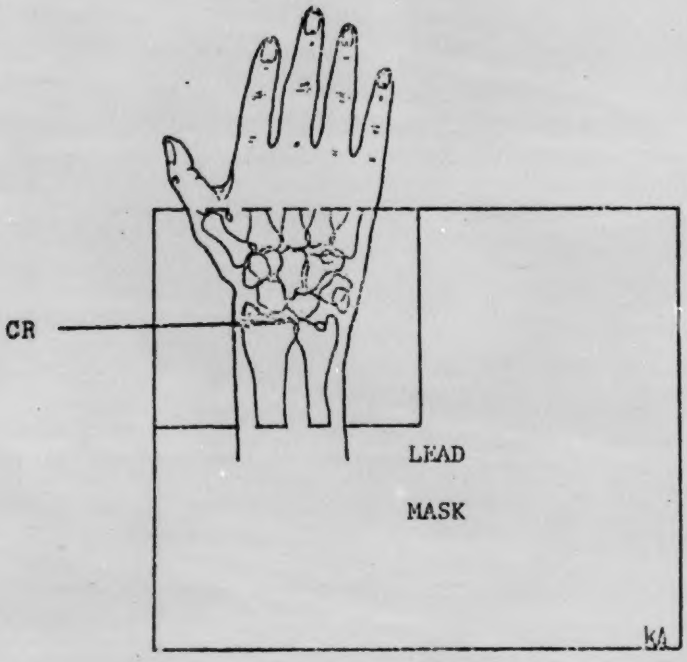
2. Positions

3. Demonstration

B. Closing Statement: You have seen that the routine wrist consists of four views. This gives us a complete general survey of the wrist with particular emphasis on the navicular area.

Wrist

Routine: PA, PA w/Ulna Flexion, Oblique and Lateral



Wrist Position PA

PFR: Midpoint of styloid processess to center of film

Film Rundown: 1 10 x 12 CW NB CR: VP Cone: FEC

Alignment: Part centered and styloids parallel to film.

Demonstratos: Wrist joint (eight) carpals, distal radius and ulna and proximal metecarpals.

Notes: FFD: 40" ID: Lateral border with lateral view.

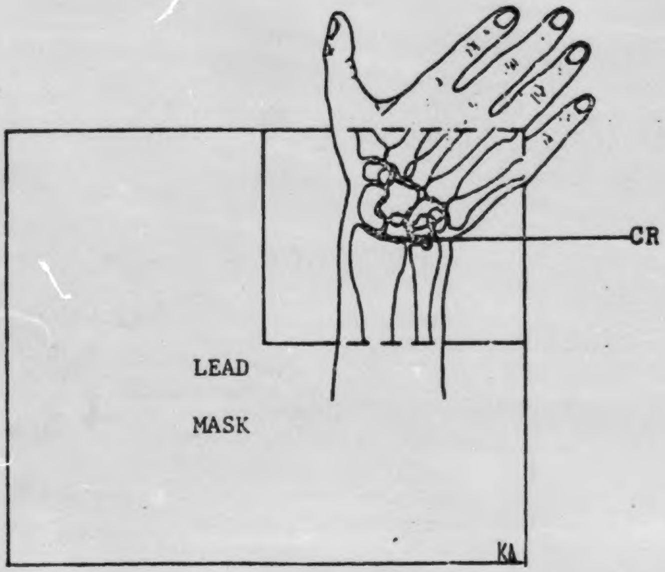
Immobilization: Place sandbags against mid-forearm. Remove all artifacts.

1) Patient may be instructed to clench fist losely to bring carpals in close contact with film

ANNEX B
INSTRUCTIONAL AIDS

Wrist

Routine: PA, PA w/Ulna Flexion, Oblique and Lateral



Wrist **Position** PA w/Ulna Flexion

PFR: Midpoint of styloid processes to center of film

Film Rundown: 1 10 x 12 CW NB **CR:** VP **Cone:** FFC

Alignment: Part centered, styloids parallel to film with hand flexed toward the ulna.

Demonstrates: Primarily: The Navicular bone. Secondarily: Same as PA.

Notes: **FFD:** 40" **ID:** Lateral border with lateral view.

1) Immobilization: Place sandbags against mid-forearm.

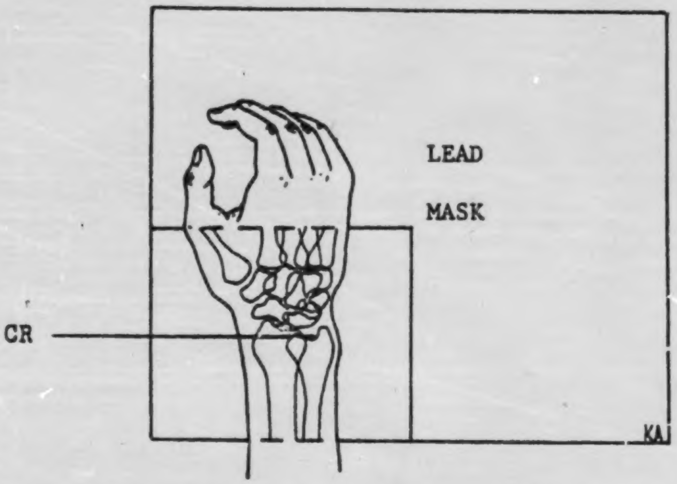
2) Flex hand off upper corner of cassette toward the lateral film border.

3) Radial flexion best demonstrates the Pisiform.

TM 8-280 pp. 10-12 Figure 10-7

Wrist

Routine: PA, PA w/Ulna Flexion, Oblique and Lateral



Wrist **Position** Oblique

PFR: Midpoint of styloid processess to center of film

Film Rundown: 1 10 x 12 CW NB **CR:** VP **Cone:** FFC

Alignment: Part centered with plane through styloids and heads of metacarpals forming a 45° angle to the film.

Demonstrates: Same as PA demonstrated in an oblique position.

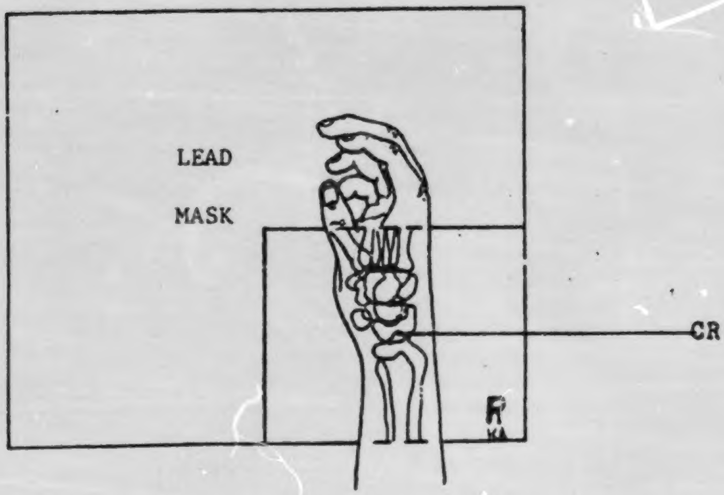
Notes: FFD: 40" **ID:** Lateral border with lateral view.

1) Immobilization: Place sandbags against mid-forearm

TM 8-280 pp. 10-13 Figure 10-8

ANNEX D
INSTRUCTIONAL AIDS
Wrist

Routine: PA, PA w/Ulna Flexion, Oblique and Lateral



Wrist **Position** Lateral

PFR Midpoint of styloid processess to center of film

Film Rundown: 1 10 x 12 CW NB **CR:** VP **Cone:** FFC

Alignment: Part centered, flex elbow 90° and supinate the wrist 5° to superimpose the styloids in a true lateral position

Demonstrates: Same as PA in lateral position.

Notes: **FFD:** 40" ID: Lateral border with lateral view.

Immobilization: Place sandbags against mid-forearm.

TM 8-280 pp. 10-14 Figure 10-9

910

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*LP 38-520-033
076

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE & SURGERY
X-RAY BRANCH

Positioning of Upper Extremity: Forearm (1 hour)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES:

TM 8-280, pp 10-15 thru 10-16
Merrill, Vinita. Atlas of Roentgenographic Positions. 3d ed. Vol. I. St Louis: C.V. Mosby Company, 1967, pp 32-35

STUDY ASSIGNMENT: After class study GR 38-520-027-1 and TM 8-280, pp 1015 thru 10-16

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 and GR 38-520-027-1

TOOLS, EQUIPMENT, AND MATERIALS: GR-520-027-1 issued at beginning of third week

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Chalk, chalkboard, eraser; PA system with lapel mike; Radiographs of the forearm, pointer, radiographic illuminator, reference diagrams of upper extremity positioning (see Annexes A thru D)

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

I. INTRODUCTION (2 min)

A. Opening Statement: The forearm is a frequent area of injury due to its position on the body and its mobility. Most injuries occur when the forearm is struck or when used to stop a fall. Since most injuries to this area are quite painful, it is important to perform a diagnostic exam the first time.

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*This lesson plan supersedes LP 38-520-033, 113

B. Objectives

1. Identify by name the position and anatomical structures demonstrated of the routine views of the distal and proximal forearm.

2. State the correct routine, PFR/CRPR, film rundown, cone-field, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization, film identification and captioning necessary to demonstrate the position(s) of the routine views of the distal and proximal forearm.

3. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiograph(s) of the routine distal and proximal views of the forearm.

C. Class Procedure and Lesson Tie-in

1. Students will gather round the X-ray table during the demonstration.

2. Students will be demonstrating these positions in their laboratory practical exercise on crucial objectives.

II. EXPLANATION/DEMONSTRATION (40 min)

A. Anatomical Structures Demonstrated - Forearm

NOTE: Place radiographs on the viewbox and point out the following anatomical structures.

1. Distal radius and ulna
   a. Base of radius
   b. Lateral styloid process
   c. Head of ulna
   d. Medical styloid process
2. Proximal radius and ulna
   a. Head of radius
   b. Olecranon process of ulna

c. Semilunar notch

d. Epicondyles of humerus

QUESTION: Where is the head of the radius located?

ANSWER: At the proximal end.

B. Positions

NOTE: Refer to Annexes A thru D for explanation of positions and have the students fill in their GR's.

1. AP (routine-distal or proximal)
2. Lateral (routine-distal or proximal)

QUESTION: What is the PFR for the distal forearm?

ANSWER: Styloid processes two inches above the lower border.

C. Demonstrate Positions Using Information in Annex A thru D.

NOTE: Positions will be demonstrated by the instructor using a student from the class as a patient and refer students to the order of procedure.

QUESTION: What is the PFR for the proximal forearm?

ANSWER: Epicondyles two inches below the upper border.

NOTE: The distal forearm routine best demonstrates Colle's fracture.

D. Questions from Students

NOTE: Make Study Assignment: After class study GR 38-520-027-1 and TM 8-280, pp 10-15 thru 10-16.

III. SUMMARY (3 min)

A. Review of Main points.

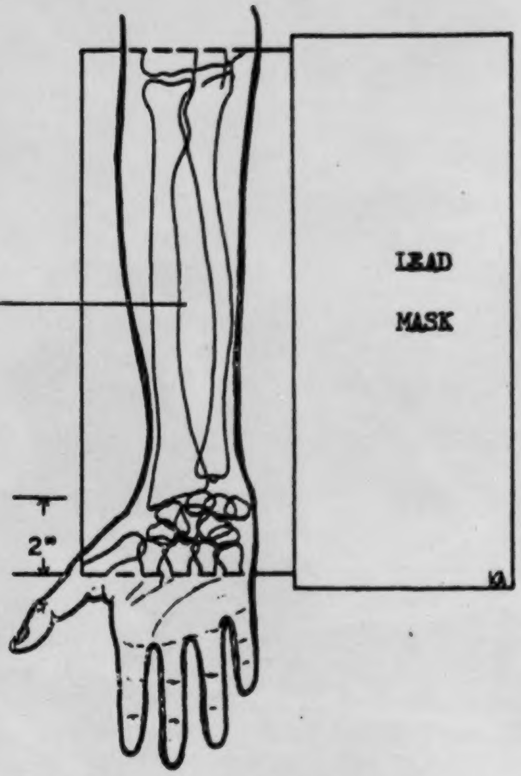
1. Anatomical Structures
2. Positions
3. Demonstration

B. Closing Statement: Since the radius and ulna are located close together in the forearm, proper positioning is important to prevent the bones from obscuring an injury that may otherwise be seen by the radiologist.

ANNEX A
INSTRUCTIONAL AIDS

Forearm

Routine: Distal Forearm AP and Lateral



Distal Forearm Position AP

PFR: Styloid processes 2" above the lower border of film holder.

Film Rundown: 1 10 x 12 LW NB CR: VP Cone: FFC

Alignment: Part centered. Epi's and Styloids parallel as nearly as possible to film.

Demonstrates: Wrist joint and distal 2/3 of Radius and Ulna.

Notes: FFD: 40". TD: Either lateral border.

Immobilization: Place sandbags across extended fingers of hand.

1) All long bones must include one joint — the joint nearest the site of injury. 2) The length of the bone is placed to the length of the film.
3) Remove artifacts.

TM 8-280 pp. 10-15 FIGURE 10-10

ANNEX B
INSTRUCTIONAL AIDS
Forearm

LP 38-520-033
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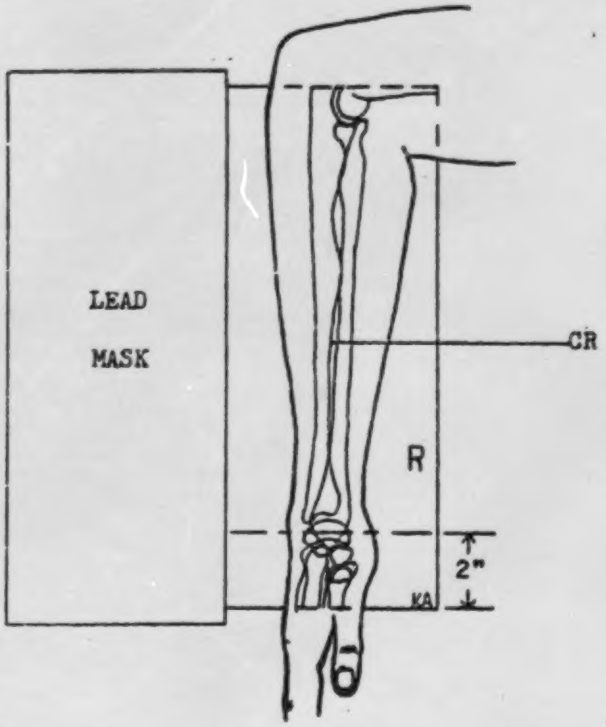
Routine: Distal Forearm AP and Lateral



Distal Forearm Position Lateral

PFR: Styloid processess 2" above the lower border of film holder

Film Rundown: 1 10 x 12 LW NB CR: VP Cone: FFC

Alignment: Part centered, elbow flexed 90° with Epi's and Styloids perpendicular as nearly as possible to the film.

Demonstrates: Wrist joint and distal 2/3 of Radius and Ulna

Notes: FFD: 40" ID: Either lateral border

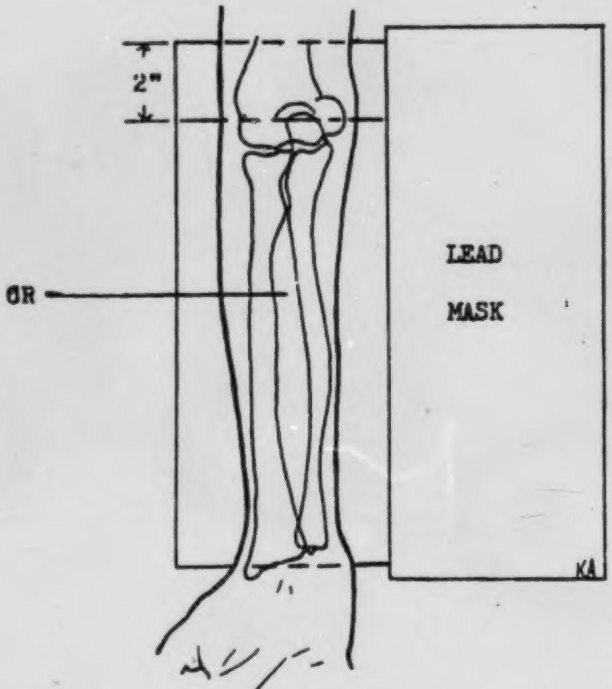
1. Immobilization: Place sandbags against sides of extended fingers.
2. This routine best demonstrates Colles' Fracture. Colle's Fracture: A fracture of the distal radius with posterior displacement of the distal fragments.
3. Remove Artifacts.

TM 8-280 pp. 10-16 Figure 10-11

ANNEX C
INSTRUCTIONAL AIDS

Forearm

Routine: Proximal Forearm AP and Lateral



Proximal Forearm Position AP

PFR: Epicondylas 2" below the upper border of film holder

Film Rundown: 1 10 x 12 LW NB CR: VP Cone: FFC

Alignment: Part centered, Epi's and Styloids parallel as nearly as possible to the film.

Demonstrates: Elbow joint and proximal 2/3 of Radius and Ulna

Notes: FFD 40" ID: Either lateral border

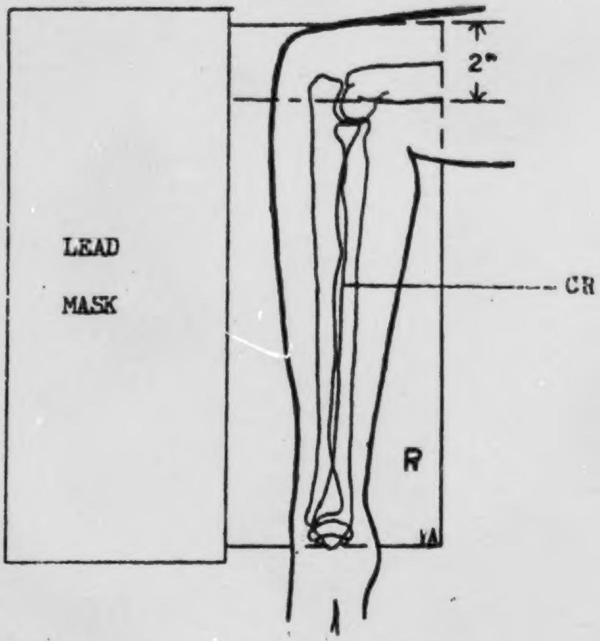
Immobilization: Place sandbag in palm of hand.

1) Shoulder should be at the level of the table top.

2. Remove artifacts.

Forearm

Routine: Proximal Forearm AP and Lateral



Proximal Forearm Position Lateral

PFR: Epicondyles 2" below the upper border of film holder

Film Rundown: 1 10 x 12 LW NB CR: VP Cone: FEC

Alignment: Part centered, elbow flexed 90° with Epi's and Styloids perpendicular as nearly as possible to the film.

Demonstrates: Elbow joint and proximal 2/3 of Radius and Ulna

Notes: FFD: 40" ID: Either lateral border

Immobilization: Place sandbags against sides of extended fingers.

1. Remove artifacts.

TM 8-280 pp. 10-16 Figure 10-11

917

SFC JIMMIE BINKLEY
*LP 38-520-034
076

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE & SURGERY
X-RAY BRANCH

Positioning of Upper Extremity: Elbow (1 hour)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES:

TM 8-280, pp 10-17 thru 10-19.
Merrill, Vinita. Atlas of Roentgenographic Positions. 3d ed. Vol. I. St Louis: C.V. Mosby Company, 1967, pp 48-52

STUDY ASSIGNMENT: After class study GR 38-520-027-1 and TM 8-280, pp 10-17 thru 10-19.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 and GR 38-520-027-1

TOOLS, EQUIPMENT, AND MATERIALS: GR 38-520-027-1 issued at beginning of third week

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Chalk, chalkboard, and eraser; PA system with lapel mike; Radiographs of the elbow, pointer, and X-ray illuminator (see Annexes A thru C)

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

I. INTRODUCTION (2 min)

A. Opening Statement: Have you ever seen a person who could not fully straighten his arm because of an old fracture of the elbow? There could be many reasons why this person is not able to straighten his arm, one of which might have been the specialist's lack of knowledge when the initial radiographs of the injured elbow were made. A diagnostic radiograph will help the medical officer in making a quick diagnosis and in treating the extremity; therefore, you, as a future X-ray Specialist, must have a thorough knowledge of positioning the elbow to insure diagnostic radiographs.

---

*This lesson plan supersedes LP 38-520-034, 113.

B. Objectives

1. Identify by name the position and anatomical structures demonstrated of the routine and additional views of the elbow.

2. State the correct routine, PFR/CRPR, film rundown, cone-field, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization, film identification and captioning necessary to demonstrate the position(s) of the routine and additional views of the elbow.

3. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiograph(s) of the routine and additional views of the elbow.

C. Class Procedure and Lesson Tie-in

1. Students will gather around the X-ray table during the demonstration.

2. Students will be demonstrating these positions in their laboratory practical exercise on crucial objectives.

II. DEMONSTRATION (40 min)

A. Anatomical Structures Demonstrated - Elbow

NOTE: Place radiographs on the viewbox and point out the following anatomical structures.

1. Proximal radius and ulna

   a. Head of radius

   b. Olecranon of ulna

      (1) Semilunar notch

      (2) Coronoid process

2. Distal humerus

   a. Epicondyles--medial and lateral

   b. Olecranon fossa--posterior aspect

c. Capitulum--anterior aspect (Lateral Aspect)

d. Trochlea--anterior aspect (Medial Aspect)

QUESTION: What is the bony prominence on the back of the elbow?

ANSWER: Olecranon process.

B. Positions

NOTE: Refer to annexes A thru C for explanation of positions and have the students fill in their GR's.

1. AP (routine)

QUESTION: What is the PFR for the AP elbow?

ANSWER: Midpoint of epicondyles to the center of the film.

2. Lateral (routine)

QUESTION: What is the relationship of the epicondyles to the film when doing the lateral elbow?

ANSWER: The epicondyles are perpendicular to the film.

NOTE: Stress that the elbow and the shoulder are on the same plane.

3. Jones' view (additional)

NOTE: Explain that the Jones' view is named after a Dr. Jones who devised the position for surgical repair of supra-condylar fractures of the humerus.

C. Demonstrate Positions Using Information in Annex A thru C.

NOTE: Positions will be demonstrated by the instructor using a student from the class as a patient and refer students to the order of procedure.

QUESTION: What is the PFR for the Jones' view?

ANSWER: Epicondyles to the center of the film.

NOTE: Emphasize that the epicondyles are parallel to the film.

D. Questions from Students

NOTE: Make Study Assignment: After class study GR 38-520-027-1 and TM 8-280, pp 10-17 thru 10-19.

III. SUMMARY (3 min)

A. Review of Main Points

1. Anatomical Structures

2. Positions

3. Demonstration

B. Closing Statement: Keep in mind that a hinge will not work if there is a crack or foreign object, such as a piece of sand in it. The same is true with the elbow which is a hinge joint, but unlike a steel hinge, the elbow cannot be forced to open or close without causing severe damage.

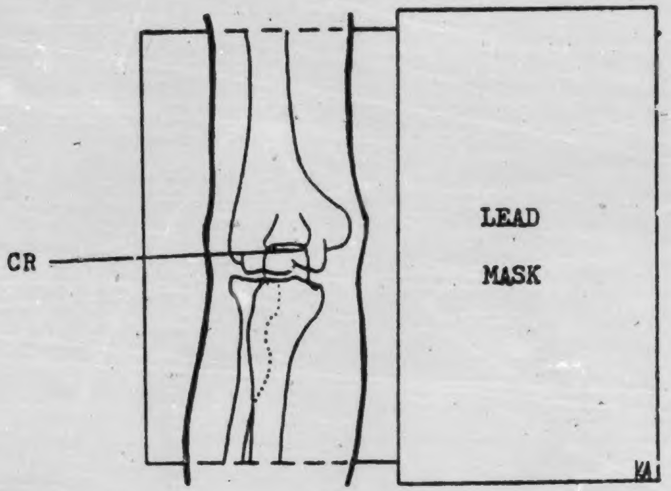
ANNEX A
INSTRUCTIONAL AIDS

LP 38-520-034
076

Elbow

Routine: AP and Lateral

Additional: Jones



Elbow **Position** AP

PFR: Midpoint of Epicondyles to center of film

Film Rundown: 1 10x12 CW NB **ID:** Either lateral border

CR: VP **Cone:** FFC

Alignment: Part centered with Epicondyles parallel to the film.

Breathing Technique: **FFD:** 40"

Demonstrates: Elbow joint, proximal Radius and Ulna and distal Humerus.

Notes: Immobilization: Place sandbag in palm of hand.

1) Shoulder should be at the level of the table top.

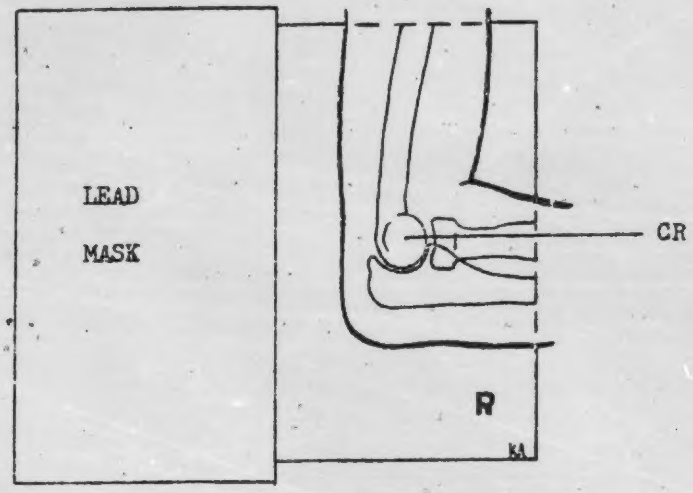
TM 8-280 pp. 10-17 Figure 10-12

ANNEX B
INSTRUCTIONAL AIDS

Elbow

Routine: AP and Lateral

Additional: Jones



Elbow **Position** Lateral

PFR: Midpoint of Epicondyles to center of film

Film Rundown: 1 10x12 CW NB **ID:** Either lateral border.

CR: VP **Cone:** FFC

Alignment: Part centered, forarm flexed 90 with epicondyles and styloids perpendicular to the film.

Breathing Technique: **FFD:** 40"

Demonstrates: Elbow joint, proximal Radius and Ulna and distal Humerus.

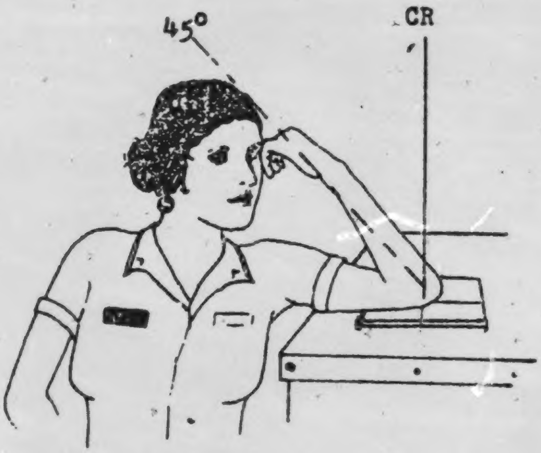
Notes: Immobilization: Place sandbags against forearm on both sides.

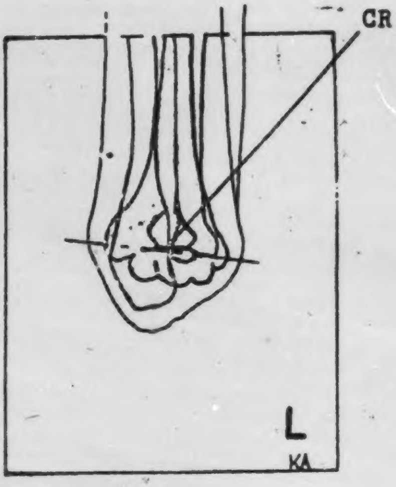
1) Humerus enters from the upper film border and forearm extends off the lateral film border.

Elbow

Routine: AP and Lateral

Additional: Jones





Elbow **Position** Jones

PFR: Midpoint of epicondyles to center of film.

Film Rundown: 1 8x10 LW NB **ID:** Either lateral border.

CR: VP **Cone:** FFC

Alignment: Part centered with Epicondyles parallel to the film. Humerus and forarm hyperflexed forming a 45° angle. Palm facing down.

Breathing Technique: **FFD:** 40"

Demonstrates: Olecranon process and distal Humerus.

Notes: Immobilization: Have patient hold hand of affected extremity with other hand.

1) Jones and lateral views of Elbow best demonstrate the Olecranon process.

TM 8-280 pp. 10-18 Figure 10-13

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DIVISION OF MEDICINE AND SURGERY 066
X-RAY BRANCH

924

Positioning of Upper Extremity: Humerus (2 hours)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES:

TM 8-280, pp 10-21, 10-22, and 10-24
Merrill, Vinita. Atlas of Roentgenographic Positions. 3d ed, Vol I
St. Louis: C.V. Mosby Company, 1967, pp 56-57

STUDY ASSIGNMENT: After class study GR 38-520-027-1 and TM 8-280, pp 10-21, 10-22, and 10-24.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 and GR 38-520-027-1

TOOLS, EQUIPMENT, AND MATERIALS: GR 38-520-027-1 issued at beginning of third week

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Chalk, chalkboard, and eraser; PA system with lapel mike; Radiographs of the Humerus, pointer, and X-ray illuminator (See Annexes A through E)

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

I. INTRODUCTION (5 min)

A. Opening Statement: Have you ever seen a person who could not fully straighten his arm because of an old fracture of the lower portion of the humerus? There could be many reasons why this person is not able to straighten his arm, one of which might have been the specialists's lack of knowledge when the initial radiographs of the injured extremity were made. A diagnostic radiograph will help the medical officer in making a quick diagnosis and in treating the extremity; therefore, you, as a future X-ray Specialist, must have a thorough knowledge of positioning the humerus to insure diagnostic radiographs.

---

*This lesson plan supersedes LP 38-520-035, 123; 38-520-060

B. Objectives

1. Identify by name the position and anatomical structures demonstrated of the routine views of the distal and full length humerus, and transthoracic humerus.

2. State the correct routine, PRF/DRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, immobilization, breathing technique, film identification and captioning necessary to demonstrate the position(s) of the routine views of the distal and full length humerus, and transthoracic humerus.

3. Given a request slip and a simulated patient in the x-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiograph(s) of the routine views of the distal and full length humerus, and transthoracic humerus.

C. Class Procedure and Lesson Tie-in

1. Students will gather around the x-ray table during the demonstration.

2. Students will be demonstrating these positions in their laboratory practical exercise on crucial objectives.

II. DEMONSTRATION (80 min)

A. Anatomical Structures Demonstrated - Distal Humerus

NOTE: Place radiographs on the viewbox and point out the following anatomical structures.

1. Distal humerus

   a. condyles and epicondyles

   b. Shaft

2. Proximal forearm

   a. Radius

   b. Ulna

NOTE: The distal humerus and the proximal forearm form the elbow joint.

B. Positions

NOTE: Refer to Annexes A and B for explanation of positions and have the students fill in their GR's.

1. AP Distal (routine)

QUESTION: Which side of the film should the AP view be placed on?

ANSWER: Right side for right humerus, and left side for left humerus.

2. Lateral Distal (routine)

QUESTION: Why do we flex the elbow 90 degrees for the lateral view?

ANSWER: It must be done to get a true lateral position.

QUESTION: What must be particularly remembered when radiographing long bones?

ANSWER: Length of the film to the length of the bone.

C. Demonstrate Positions Using Information in Annex A and B.

NOTE: Positions will be demonstrated by the instructor using a student from the class as a patient and refer students to the order of procedure.

SECOND HOUR

D. Anatomical Structures Demonstrated - Full Length Humerus and Trans-Thoracic Humerus.

NOTE: Place radiograph on viewbox and point out the following anatomical structures.

1. Head
2. Greater tuberosity
3. Lesser tuberosity
4. Bicipital groove
5. Glenoid fossa
6. Surgical neck

E. Positions

NOTE: Refer to Annexes C through E for explanation of the positions and have the students fill in their GR's.

1. AP with external rotation (routine)

2. AP with internal rotation (routine)

QUESTION: Do we use the same part-to-film reference for both views?

ANSWER: Epicondyles are to the lower film border as the acromion process is to the upper film border.

3. Trans-thoracic (additional)

F. Demonstrate Positions Using Information in Annex C through E.

NOTE: Positions will be demonstrated by the instructor using a student from the class as a patient and refer students to the order of procedure.

QUESTION: Which view should be positioned on the film first and why?

ANSWER: External rotation, in order that we do not allow the patient to remain in an uncomfortable position for too long.

G. Questions from Students

NOTE: Make Study Assignment: After class study GR 38-520-027-1 and TM 8-280, pp 10-21 through 10-22 and 10-24

III. SUMMARY (5 min)

A. Review of Main Points

1. Anatomical Structures

2. Positions

3. Demonstration

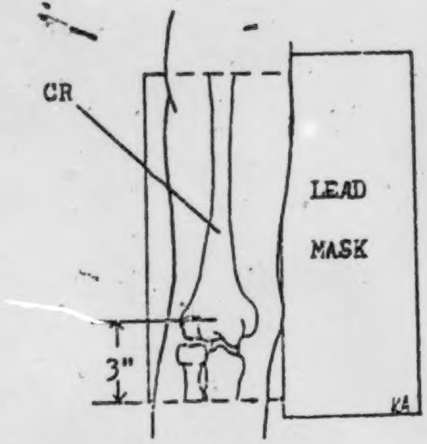
B. Closing Statement: Extreme caution must be used while positioning the patient for the humerus views to prevent further injury. The X-Ray Specialist must use good positioning and handling techniques in order to prevent this from happening, as well as producing a good diagnostic film the first time.

928

ANNEX A
INSTRUCTIONAL AIDS

Humerus

Routine: Distal Humerus AP and Lateral



Distal Humerus Position AP.

PFR: Epicondyles 3" above lower border of film holder

Film Rundown: 1 10x12 LW NB ID: Either lateral border.

CR: VP Cone: FPC

Alignment: Part centered and Epicondyles parallel to film.

Breathing Technique: FFD: 40"

Demonstrates: Distal 2/3 of Humerus and Elbow joint.

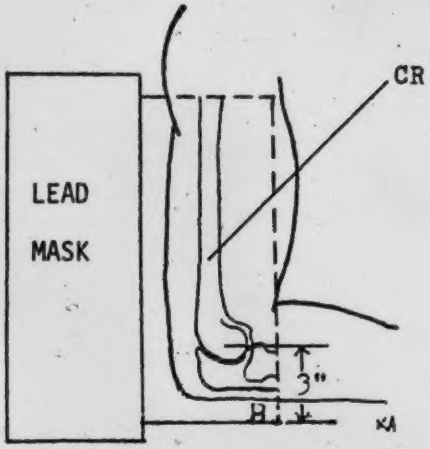
Notes: Immobolization: Place sandbags against forearm.

1) Shoulder should be at same level as table top.

ANNEX B
INSTRUCTIONAL AIDS

Humerus

Routine: Distal Humerus AP and Lateral



Distal Humerus Position Lateral

PFR: Epicondyles 3" above lower border of film holder

Film Rundown: 10 x 12 LW NB CR: VP Cone: FFC

Alignment: Part centered and elbow flexed 90° with epicondyles and styloids as nearly perpendicular as possible to film.

Demonstrates: Distal 2/3 of Humerus and Elbow joint.

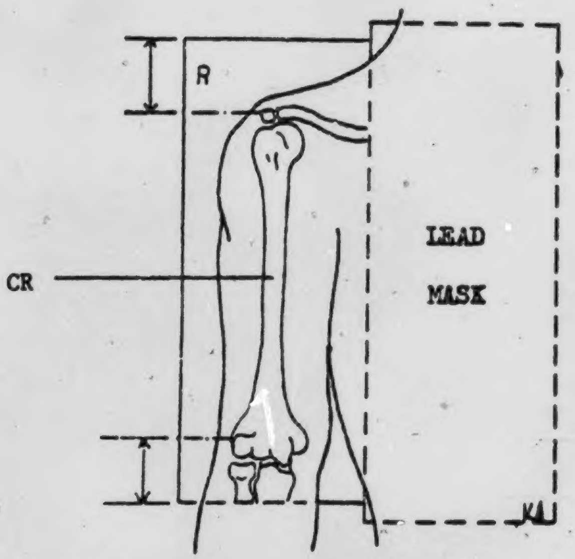
Notes: FFD; 40" ID: Either Lateral borber.

Immobilization: Place sandbags against forearm

1. Humerus enters from the upper border and forearm extends off the lateral film border.

Humerus

Routine: Full Length Humerus AP with External Rotation (palm up)
AP with Internal Rotation (palm out)



Full Length Humerus Position AP w/ External Rotation (palm up)

PFR: Epicondyles are to the lower film border as the acromion process is to the upper film border.

Film Rundown: 1 14 x 17 LW NB CR: VP Cone: FEC

Alignment: Part centered with Epicondyles parallel to film

Breathing Technique: Suspended Respiration

Demonstrates: Full Length Humerus in AP position

Notes: FFD: 40" ID: Either lateral border

Immobilization: Place sandbag in palm of hand.

1) External Rotation the Greater Tuberosity is demonstrated on lateral aspect of Humeral head.

2) Cathode reference - Cephalic.

TM 8-280 pp. 10-21 Figure 10-16

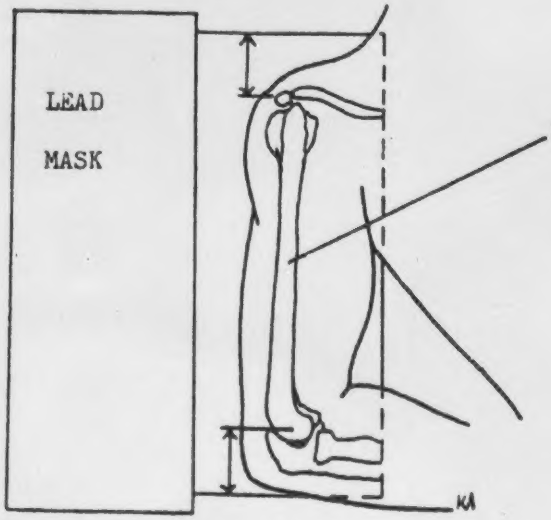
931

ANNEX D
INSTRUCTIONAL AIDS

Humerus

Routine: Full Length Humerus AP with External Rotation (Palm Up)

AP with Internal Rotation (Palm Out)



Full Length Humerus Position AP with Internal Rotation (Palm Out)

PFR: Epicondyles are to the lower film border as the Acromion Process is to the upper film border.

Film Rundown: 14 x 17, LW, NB CR: VP Cone: FFC

Alignment: Part centered with Epicondyles perpendicular to film

Breathing Technique: Suspended Respiration

Demonstrates: Full length humerus in lateral position

Notes: FFD: 40" ID: Either lateral border

1. IMMOBILIZATION: Place sandbag against turned out palm
2. Internal rotation, the Greater Tuberosity is superimposed over the humeral head.
3. Cathode Reference: Cephalic

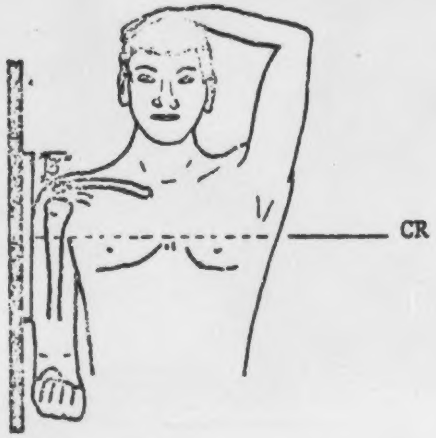
933

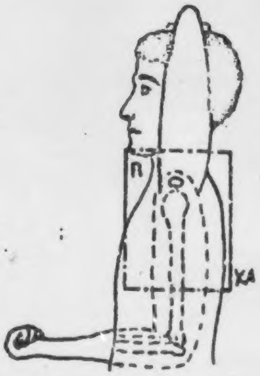
TM 8-280 pp. 10-22 Figure 10-17

932

Humerus

Additional Position: Trans-thoracic





PFR: Acromion Process 3" below upper border of film holder

Film Rundown: 10x12, LW, B CR: HP Cone: FFC

Alignment: Part centered, Epicondyles and styloids perpendicular to film

Breathing Technique: Suspended Inspiration

Demonstrates: Head, neck and upper 2/3 of humerus

Notes: FFD: 40" ID: Either lateral border

1. When possible, the forearm of the affected side should be raised and positioned parallel to the floor, palm up and epicondyles perpendicular to the film. 2. Suspended inspiration for short scale of contrast. 3. May be refered to as Lawrence Position 4. Patient Dress: Clothing from waist up removed and placed in a gown.

934

TM 8-280 pp. 10-24 Figure 10-19

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076

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

Positioning of Upper Extremity: Shoulder (1 hour)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES:

TM-8-280, pp 10-25
Merrill, Vinita. Atlas of Roentgeographic Positions. 3d ed. Vol. I. St. Louis: C. V. Mosby Company, 1967, pp 124-125.

STUDY ASSIGNMENT: After class study GR 38-520-027-1 and TM 8-280, pp 10-25

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 and GR 38-520-027-1

TOOLS, EQUIPMENT, AND MATERIALS: GR 38-520-027-1 issued at beginning of third week

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Chalk, chalkboard, and eraser; PA system with lapel mike; Radiographs of the Shoulder, pointer, and X-ray illuminator (see Annexes A and B)

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

I. INTRODUCTION (2 min)

A. Opening Statement: The shoulder joint is one of two ball-and-socket joints in the body. This ball-and-socket joint allows for a vast amount of movement--flexion, extension, abduction, adduction, circumduction, and rotation. Because of the variety of movements in the shoulder, you can realize how important it is to the normal functioning of the body.

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*This lesson plan supersedes LP 38-520-036, 113

934

B. Objectives

1. Identify by name the position and anatomical structures demonstrated of the routine views of the shoulder.

2. State the correct routine, PFR/CPR, film rundown, cone-field, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization, film identification and captioning necessary to demonstrate the position(s) of the routine views of the shoulder.

3. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiograph(s) of the routine views of the shoulder.

C. Class Procedure and Lesson Tie-in

1. Students will gather around the X-ray table during the demonstration.

2. Students will be demonstrating these positions in their laboratory practical exercise on crucial objectives.

II. DEMONSTRATION (40 min)

A. Anatomical Structures Demonstrated - Shoulder

NOTE: Place radiographs on the viewbox and point out the following anatomical structures.

1. Humerus
   a. Shaft
   b. Neck
   c. Head
   d. Greater tuberosity

NOTE: Greater tuberosity is seen on external rotation on the lateral aspect of the Humeral head.

2. Scapula
   a. Coracoid process
   b. Acromion process
   c. Glenoid fossa

3. Clavice

4. Ribs

5. Lung Field

QUESTION: Name two palpation points on the scapula that are seen on a routine shoulder?

ANSWER: (1) Acromion process, and (2) coracoid process.

B. Positions

NOTE: Refer to Annexes A and B for explanation of positions and have the students fill in their GR's.

1. AP w/internal rotation (routine)

2. AP w/external rotation (routine)

C. Introduction to the Use of Grids

1. Purpose--to reduce the amount of the secondary radiation striking the film.

2. Types

a. Stationary

(1) Focused

(2) Nonfocused

b. Grid cassettes

c. Reciprocating

QUESTION: What are the three types of grids used in the military clinic?

ANSWER: (1) stationary, (2) grid cassette, and (3) reciprocating.

D. Demonstrate Positions Using Information in Annexes A and B.

NOTE: Positions will be demonstrated by the instructor using a student from the class as a patient and refer students to the order of procedure.

NOTE: Emphasize the importance of patient being dressed in dressing gown for this procedure.

QUESTION: What is the PFR for the routine shoulder view?

936

LP 38-520-036
076

ANSWER: Coracoid process to the center of the film.

E. Questions From Students

NOTE: Make Study Assignment: After class study GR 38-520-027-1 and TM 8-280, pp 10-25

III. SUMMARY (3 min)

A. Review of Main Points

1. Anatomical Structures

2. Positions

3. Demonstration

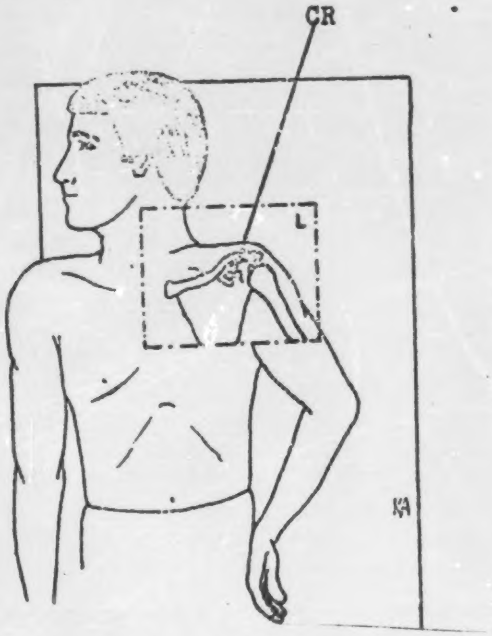
B. Closing Statement: Proper positioning of the routine shoulder will enable you to produce diagnostic radiographs in an efficient manner with the utmost care to the patients.

LP 38-520-036
076

ANNEX A
INSTRUCTIONAL AIDS

Shoulder

Routine: AP Shoulder w/ Internal Rotation (palm out) and External Rotation (palm up)



AP Shoulder w/ Position Internal Rotation

PFR: Coracoid Process to center of film

Film Rundown: 1 10x12 CW B CR: VP Cone: FFC

Alignment: Part centered and Epicondyles perpendicular to table

Breathing Technique: Suspended Expiration (to obtain uniform density)

Demonstrates: Shoulder joint with Greater Tuberosity superimposed over the Humeral head.

Notes: FFD: 40" ID: Above the part reading down.

Immobilization: Place sandbag against turned out palm.

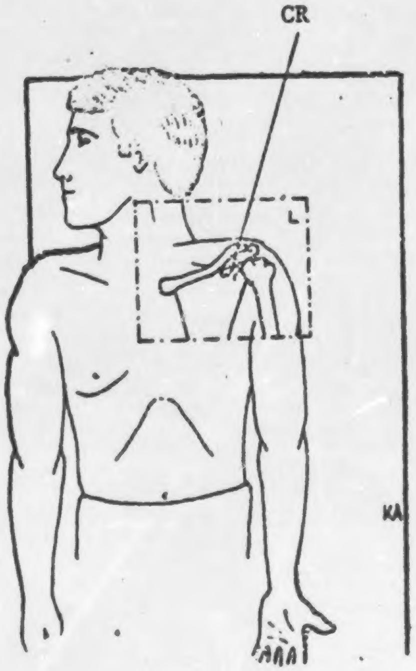
1) Patient dress should be dressing gown to assure artifact free film and to afford patient privacy during examination.

TM 8-280 pp. 10-25 Figure 10-20

ANNEX B
INSTRUCTIONAL AIDS

Shoulder

Routine: AP Shoulder w/ Internal Rotation (Palm out) and External Rotation (palm up)



AP Shoulder **Position** External Rotation (palm up)

PFR: Caracoid Process to center of film

Film Rundown: 1 10x12 CW B CR: VP Cone: FFC

Alignment: Part centered and Epicondyles parallel with the table

Breathing Technique: Suspended Expiration

Demonstrates: Shoulder joint with the Greater Tuberosity on the lateral aspect of the Humeral head.

Notes: FFD: 40" ID: Above the part reading down.

Immobilization: Place sandbagin open palm.

1) Patient dress same as Internal Rotation view.

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X-RAY BRANCH

Positioning of the Shoulder Joint (1 hour)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES:

TM 8-280, pp 10-23.
Merrill, Vinita. Atlas of Roentgenographic Positions. 3d ed. Vol 1. St Louis: C.V. Mosby Company, 1967, pp 132-133.
Sante, L.R. Manual of Roentgenological Technique. Ann Arbor, Michigan: J.W. Edwards, Inc., 1956, pp 316-318.

STUDY ASSIGNMENT: After class study GR 38-520-027-1 and TM 8-280, pp 10-23

STUDENT UNIFORM AND EQUIPMENT: TM 8-820 and GR 38-520-027-1

TOOLS, EQUIPMENT AND MATERIALS: GR 38-520-027-1 issued at beginning of third week

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Radiographs of inferior-superior and superior shoulder joint (see Annexes A and B), radiographic illuminator, pointer, typical radiographic setup; Chalk, chalkboard, and eraser

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

I. INTRODUCTION (5 min)

A. Opening Statement: The positions which we shall cover during this period are not frequently encountered. However, we, as X-Ray Specialists, must be able to perform these positions with a minimum of difficulty. The prime purpose of either the inferior-superior or superior-inferior view is to demonstrate the humeral head and glenoid fossa. However, it is sometimes used to demonstrate shoulder dislocation.

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*This lesson plan supersedes LP 38-520-0610, 034

940

B. Objectives

1. Identify by name the position and anatomical structures demonstrated of the I-S and S-I shoulder joint.

2. State the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization, film identification and captioning necessary to demonstrate the position(s) of the I-S and S-I shoulder joint.

3. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiograph(s) of the I-S and S-I shoulder joint.

C. Class Procedure and Lesson Tie-in

1. Students will gather around the X-ray table during the demonstration.

2. Students will be demonstrating these positions in their laboratory crucial/practical exercises.

II. DEMONSTRATION (35 min)

A. Anatomical Structures Demonstrated - S-I and I-S shoulder.

1. Proximal humerus

2. Glenoid fossa

QUESTION: What two anatomical structures are we primarily interested in?

ANSWER: The head of the humerus and glenoid fossa.

B. Positions

NOTE: Refer to Annexes A and B for explanation of positions and have the students fill in their GR's.

NOTE: Use radiographs to demonstrate positions.

1. Routine--superior-inferior (S-I)

2. Additional view--inferior-superior (I-S)

QUESTION: What is the central ray to part reference for the superior-inferior shoulder joint?

ANSWER: Acromion process to center the film.

NOTE: Emphasize--the patient's ability to abduct his arm to a near right angle should be verified before superior-inferior shoulder joint position is undertaken.

NOTE: This is an excellent view to demonstrate the glenoid fossa. It is also used to demonstrate shoulder dislocations.

QUESTION: What is the angle and direction of the central ray for the superior-inferior shoulder joint?

ANSWER: Fifteen degrees toward the elbow.

C. Demonstrate positions using information in Annexes A and B.

NOTE: Position will be dmonstrated by the instructor using a student from the class as a patient and refer students to the order of procedure.

D. Questions from Students

NOTE: Make study assignment: Study TM 8-280, pp 10-23 and GR 38-520-027-1.

III. SUMMARY (5 min)

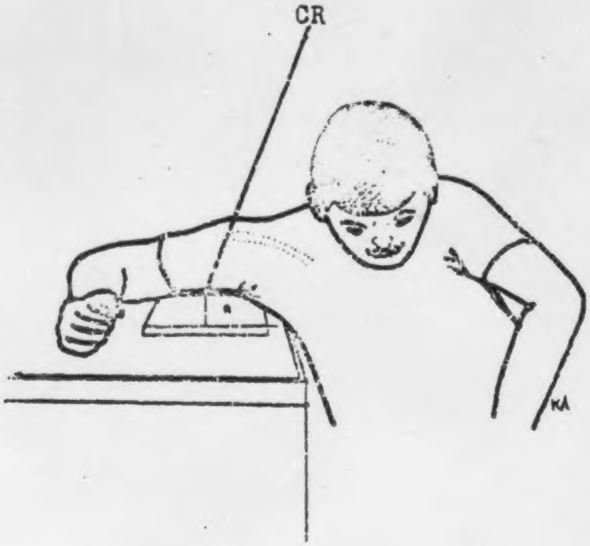
A. Review of Main Points

1. Anatomical Structures
2. Positions
3. Demonstration

B. Closing Statement: While these two views of the shoulder joint are not frequently requested, careful application of the material presented will make this examination relatively easy.

ANNEX A
INSTRUCTIONAL AIDS

Superior-Interior Shoulder Joint, Head and Neck of Humerus



CRPR: Acromion process to the center of the film.

Film Rundown: 8x10, CW, NB CR: 15° toward elbow Cone: FFC

Alignment: Epicondyles perpendicular, arm and forearm form a 90° angle.

Breathing Technique. Suspended respiration

Demonstrates: Head of humerus and glenoid fossa

Notes: FFD: 40" ID: Above part

1. IMMOBILIZATION: Place sand bags against both sides of the forearm.

2. The patient should be in a dressing gown for this procedure. Undergarments removed from shoulder to waist. Necklace removed etc.

3. Patient's ability to abduct arm to a near right angle should be verified before this position is undertaken.

4. TM 8-280 explains this position can be taken with a VP CR. Both methods are acceptable.

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TM 8-280 pp. 10-23 Figure 10-15

[illegible]
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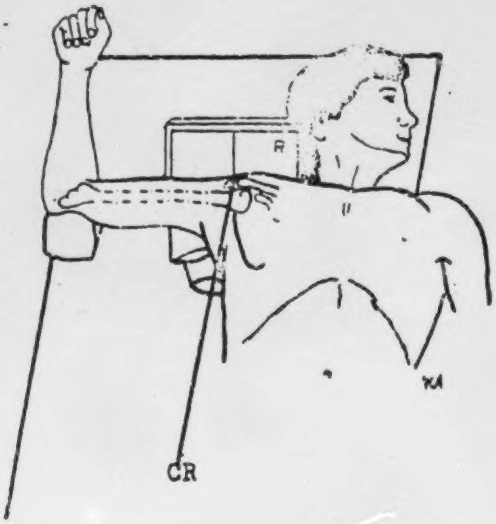
ANNEX B
INSTRUCTIONAL AIDS

Additional view: Inferior-Superior Shoulder Joint, Head and Neck of Humerus



PFR: Acromion process to the center of the film

Film Rundown: 8x10, LW, NB CR: HP & 20° medially Cone: FFC

Alignment: Part centered, Epicondyles parallel to the table top.

Breathing Technique: Suspended respiration

Demonstrates: Inferosuperior projection of the glenohumeral joint, Lateral portion of coracoid process and the acromioclavicular articulation.

Notes: FFD: 40" ID: Above part

1. IMMOBILIZATION: Place sponge cushion under patient's shoulder and elbow to raise part to center of the film.. Sand bags placed on both sides of the forearm.

2. This view is ideal when patient is in an aeroplane splint or abduction cast.

3. Patient dress is the same as for superior-inferior view.

TM 8-280 pp 10-23 Figure 10-18

944

SFC JIMMIE BINKLEY
*LP 38-520-037
076

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE & SURGERY
X-RAY BRANCH

Positioning of Upper Extremity: Scapula (1 hour)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES:

TM 8-280, pp 10-26 and 10-27
Merrill, Vinita. Atlas of Roentgenographic Positions. 3d ed. Vol. I. St Louis: C.V. Mosby Company, 1967, pp 144-145.

STUDY ASSIGNMENT: After class study GR 38-520-027-1 and TM 8-280, pp 10-26 and 10-27.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 and GR 38-520-027-1

TOOLS, EQUIPMENT, AND MATERIALS: GR 38-520-027-1 issued at beginning of third week

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Chalk, chalkboard, and eraser; PA system with lapel mike; Radiographs of the scapula, pointer, and X-ray illuminator (see Annexes A and B)

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

I. INTRODUCTION (2 min)

A. Opening Statement: The examination of the scapula is not performed often in an X-ray clinic, but when it is X-rayed, it is most often done incorrectly. This is usually the result of the specialist's lack of knowledge or lack of pride in his work. We give you the knowledge necessary in positioning the scapula; you supply the pride.

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*This lesson plan supersedes LP 38-520-037, 103.

B. Objectives

1. Identify by name the position and anatomical structures demonstrated of the routine views of the scapula.

2. State the correct routine, PFR/CRPR, film rundown, cone-field, angle and direction of the central ray; FFD, alignment, breathing technique, immobilization, film identification and captioning necessary to demonstrate the positions of the routine views of the scapula.

3. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiograph of the routine views of the scapula.

C. Class Procedure and Lesson Tie-in

1. Students will gather around the X-ray table during the demonstration.

2. Students will be demonstrating these positions in their laboratory practical exercise on crucial objectives.

II. DEMONSTRATION (40 min)

A. Anatomical Structures Demonstrated - Scapula

NOTE: Place radiographs on the viewbox and point out the following anatomical structures.

1. Scapula
    - a. Lateral angle
    - b. Glenoid fossa
    - c. Acromion process
    - d. Axillary border
    - e. Inferior angle
    - f. Vertebral border
    - g. Medial angle (superior angle)

h. Superior border

i. Spine

j. Coracoid process

2. Clavicle

3. Ribs

4. Lung fields

5. Humerus

QUESTION: What are the three most prominent palpation points of the scapula?

ANSWER: (1) Acromion process, (2) Coracoid process, (3) Inferior angle.

B. Positions

NOTE: Refer to Annexes A and B for explanation of positions and have the students fill in their GR's.

1. AP (routine

2. Lateral (routine)

C. Demonstrate Positions Using Information in Annex A and B.

NOTE: Positions will be demonstrated by the instructor using a student from the class as a patient and refer students to the order of procedure.

NOTE: Emphasize the importance of patient being dressed in dressing gown for this procedure.

QUESTION: What is the PFR for the AP view?

ANSWER: A point two inches medial and two inches inferior from coracoid process to center.

QUESTION: What is the film rundown for the AP view?

ANSWER: 10 x 12, lengthwise, Bucky.

QUESTION: What is the PFR for the lateral view?

ANSWER: Midpoint of vertebral border to center of the film holder.

D. Questions from Students

947

NOTE: Make Study Assignments: After class study GR 38-520-027-1 and TM 8-280, pp 10-26 and 10-27.

III. SUMMARY (3 min)

A. Review of Main Points

1. Anatomical Structures

2. Positions

3. Demonstration

B. Closing Statement: The proper positioning of the scapula will aid the radiologist in obtaining a correct and speedy diagnosis of the patient's injury.

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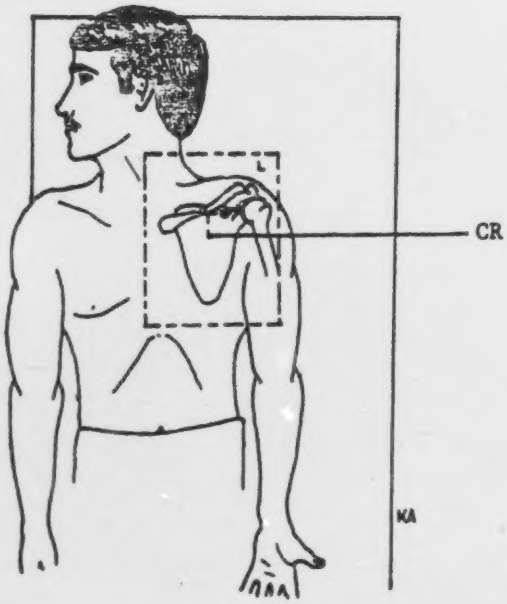
Scapula

Routine: AP and Lateral



Scapula Position AP

PFR: A point 2" medial and 2" inferior from the Coracoid Process to center of film.

Film Rundown: 1 10 x 12 LW GR: VP Cone: FFC

Alignment: Patient supine, Epicondyles parallel to table (palm up).

Breathing Technique: Suspended Expiration (to obtain uniform density)

Demonstrates: Scapula

Notes: FFD: 40" ID: Above part reading down.

Immobilization: Place sandbag in open palm.

1) Patient dress should be dressing gown to assure artifact free film.

TM 8-280 pp. 10-26 Figure 10-21

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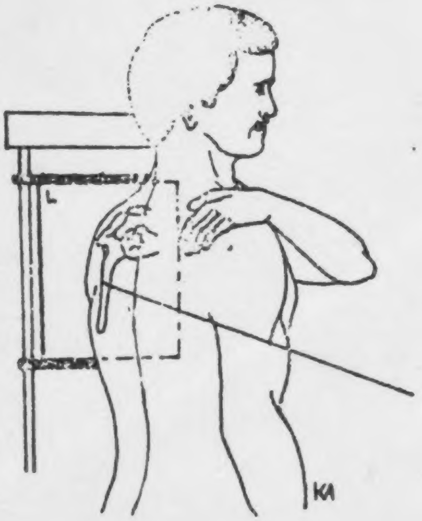
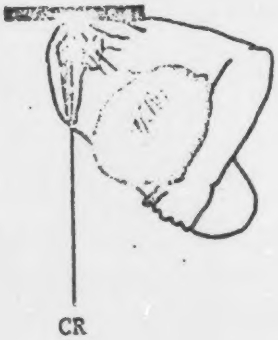
Scapula

Routine: AP and Lateral





Scapula Position Lateral

PFR: Midpoint of vertebral border to center of film.

Film Rundown: 1 10 x 12 LWB CR: HP Cone: FFC

Alignment: Acromion Process and midpoint of vertebral border are in the same vertical plane, and over the center of film.

Breathing Technique: Suspended Respiration.

Demonstrates: Scapula

Notes: FFD: 40" ID: Upper film border, reading down.

Immobilization: The hand of the affected side is placed on the opposite shoulder and suspended respiration is used.

1) Patient dress same as for AP view.

951

TM 8-280 pp. 10-22 Figure 10-27

950

SFC JIMMIE BINKLEY

ACADEMY OF HEALTH SCIENCES, US ARMY *LP 38-520-038
DIVISION OF MEDICINE & SURGERY 076
X-RAY BRANCH

Positioning of the Upper Extremity: Clavicle (1 hour)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES:

TM 8-280, pp 10-28
Merrill, Vinita. Atlas of Roentgenographic Positions. 3d ed. Vol. I. St Louis: C. V. Mosby Company, 1967, p 138.

STUDY ASSIGNMENT: After class study GR 38-520-027-1 and TM 8-280, pp 10-28

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 and GR 38-520-027-1

TOOLS, EQUIPMENT, AND MATERIALS: GR 38-520-027-1 issued at beginning of third week

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Chalk, chalkboard, and eraser; PA system with lapel mike; Radiographs of the clavicle, pointer, and X-ray illuminator (see Annexes A and B)

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

I. INTRODUCTION (2 min)

A. Opening Statement: Because of the location of the clavicle in the skeletal system and its relative mobility, the clavicle is one of the most frequently injured bones. Probably a few of you have suffered broken clavicles and know of the intense pain associated with this injury. Precise positioning must be used to insure good radiographs with as little discomfort to the patient as possible.

---

*This lesson plan supersedes LP 38-520-038, 103.

B. Objectives:

1. Identify by name the position and anatomical structures demonstrated of the routine and additional views of the clavicle.

2. State the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, immobilization, breathing technique, film identification and captioning necessary to demonstrate the position(s) of the routine and additional views of the clavicle.

3. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiograph(s) of the routine and additional views of the clavicle.

C. Class Procedure and Lesson Tie-in:

1. Students will gather around the X-ray table during the demonstration.

2. Students will be demonstrating these positions in their laboratory practical exercises on crucial objectives.

II. DEMONSTRATION (40 min)

A. Anatomical Structures Demonstrated - Clavicle

NOTE: Place radiographs on viewbox and point out the following anatomical structures.

I. Clavicle
    a. Acromial end
    b. Sternal end
2. Articulations
    a. Acromial-clavicular
    b. Sternoclavicular

B. Positions

NOTE: Refer to Annexes A and B for explanation and have the students fill in their GR's.

1. PA right (routine)

2. PA left (routine)

QUESTION: What is the PFR for the routine clavicle?

ANSWER: Midpoint of the clavicle to the center of the film.

QUESTION: How is the midpoint of the clavicle determined?

ANSWER: Midpoint between the vertebral column and the acromion process.

3. PA - Tangential (additional)

C. Demonstrate Positions Using Information in Annexes A and B.

NOTE: Positions will be demonstrated by the instructor using a student from the class as a patient and refer students to the order of procedure.

QUESTION: Why do we take bilateral views of the clavicle?

ANSWER: A right angle (or lateral) view of the PA is impracticable; therefore, a comparative view of the opposite side will help to rule out any anomalies which may exist in the patient.

NOTE: Emphasize the importance of patient being dressed in a dressing gown for this procedure.

D. Questions from Students

NOTE: Make Study Assignment: After class study TM 8-280, pp 10-28 and GR 38-520-027-1.

III. SUMMARY (3 min)

A. Review of Main Points

1. Anatomical Structures

2. Positions

3. Demonstration

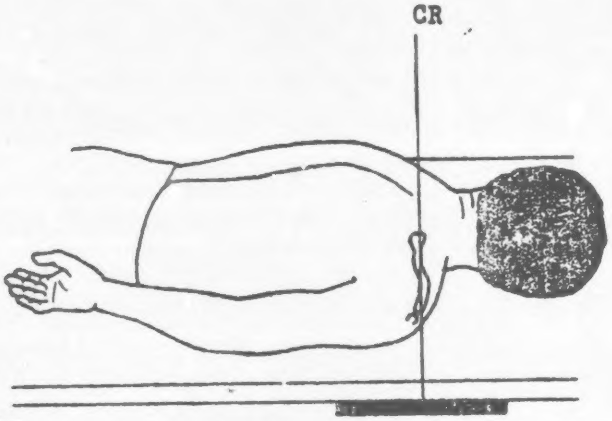
B. Closing Statement: The frequency with which clavicle fractures occur necessitates consistently good patient handling and positioning procedures. Responsible specialists must take pride in their work as instruments in the diagnosis and care of X-ray patients.

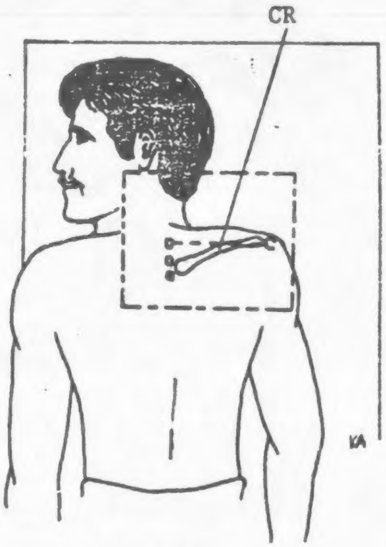
ANNEX A
INSTRUCTIONAL AIDS

Clavicle

Routine: PA Right and Left (Bi - lateral)

Additional:





Clavicle Position PA

PFR: Midpoint of Clavicle to center of film

Film Rundown: 1 10 x 12 CWB CR: VP Cone: FFC

Alignment: Midpoint between Acromion Process and spinous processes of the vertebral column over the centerline of the table.

Breathing Technique: Suspended Expiration (to obtain uniform density)

Demonstrates: Clavicle

Notes: FFD: 40" ID: Above part reading down.

Immobilization: Palm of hand facing up and sandbag placed in open palm.

1) Patient dress should be dressing gown to assure artifact free film.

2) Turn head away from affected side.

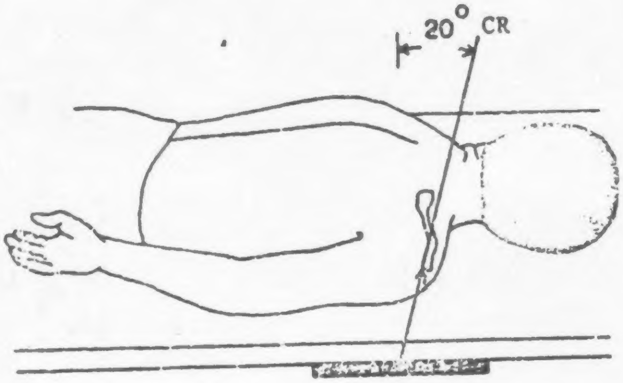
3) Bi - lateral views are required for comparison.

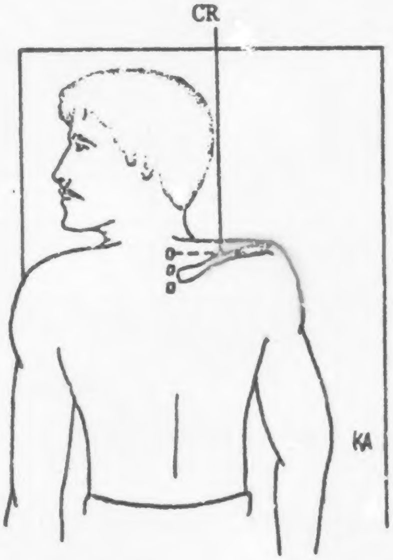
TM 9-280 pp. 10-28 Figure 10-23

Clavicle

Routine: PA right and left (Bilateral)

Additional: Tangential





Clavicle Position Tangential

CRPR: Midpoint of clavicle projected to center of film holder.

Film Rundown: 10 x 12, CW, B CR: 20° Caudad Cone: FFC

Alignment: Midpoint between Acromion Process and vertebral column over center line of table

Breathing Technique: Suspended Expiration

Demonstrates: Clavicle, to show displacement

Notes: FFD: 40 " ID: Above part reading down

Same as PA

SFC JIMMIE BINKLEY
ACADEMY OF HEALTH SCIENCES, US ARMY *LP 38-520-039
DIVISION OF MEDICINE & SURGERY 076
X-RAY BRANCH

Film Discussion: Upper Extremity (2 Hours)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES:

TM 8-230, pp 10-8 thru 10-28
Merrill, Vinita. Atlas of Roentgenographic Positions. 3d ed. Vol 1. St. Louis, Missouri: C.V. Mosby Company, 1967, pp 32-35, 40-44, 47, 48-51, 56-57, 124-125, 138, 144-145

STUDY ASSIGNMENT: After class study GR 38-520-027-1 and review 3d week film packet.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280, GR 38-520-027-1

TOOLS, EQUIPMENT, AND MATERIALS: None

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Bank of viewboxes, pointer and radiographs of the upper extremity

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

FIRST HOUR

I. INTRODUCTION: (2 min)

A. Opening Statement: A part of your job as an X-ray specialist will be to examine the radiographs that you have taken and determine if they are acceptable by clinic standards. The fact that we do not take live exposures at the school makes it necessary that we conduct these film discussions periodically during the course. For the past several days, you have been positioning the upper extremity. During this block of instruction, you will see both acceptable routines and examples of some common errors found in positioning the upper extremity.

---

*This lesson plan supersedes LP 38-520-039, 094

956

B. Objectives

1. List the routine and additional positions of the upper extremity and identify these on radiographs.

2. Given a radiograph of an upper extremity position:

   a. State the pertinent information necessary to produce that position.

   b. Identify and discuss any error(s) demonstrated on the radiograph.

   c. Identify anatomical structures demonstrated.

C. Class Procedure and Lesson Tie-in

1. This class was preceded by the following related blocks of instruction: Positioning of the Upper Extremity: Hand, Wrist, Forearm and the Elbow.

2. This class will be conducted by showing radiographs and discussing requirements for each position. Emphasis will be placed on areas as indicated by questions from the class.

II. DEMONSTRATION (38 min)

A. The Normal Radiograph

NOTE: Show one radiograph of each procedure progressing from hand through elbow. Review each, requiring students to supply the following information.

1. Name of position

2. Part-to-film holder reference

3. Film rundown

4. Central ray

5. Alignment

6. Anatomy demonstrated

7. Special considerations

958

B. Common errors

NOTE: Show one radiograph of each procedure progressing from hand through elbow. Choose radiographs that demonstrate probable incorrect procedures for each position so that several factors will be discussed.

1. Film handling
2. Positioning
3. Central ray
4. Secondary factors of exposure

C. Questions From Students

III. SUMMARY (5 min)

A. Review of Main Points

1. The normal radiograph
2. Common errors

B. Closing Statement: During this hour, you have seen examples of both acceptable and unacceptable radiographs of the upper extremity, up to and including the elbow. We will complete our film discussion on the upper extremity following your classes and practical exercises on the humerus, shoulder, scapula and clavicle.

SECOND HOUR

I. INTRODUCTION

A. Same as "FIRST HOUR"

B. Same as "FIRST HOUR"

C. Class Procedure and Lesson Tie-in

1. This class was preceded by the following related blocks of instruction: Positioning of the Upper Extremity: Humerus, Trans-Thoracic Humerus, Shoulder, Scapula, Clavicle, I-S and S-I Shoulder.

2. This class will be conducted by showing radiographs and discussing requirements for each position. Emphasis will be placed on areas as indicated by questions from the class.

II. DEMONSTRATION (40 min)

A. The normal Radiograph

NOTE: Show one radiograph of each procedure progressing from humerus through clavicle. Review each, requiring students to supply the following information.

1. Name of position
2. Part-to-film holder reference/central ray to part reference
3. Film rundown
4. Central ray
5. Alignments
6. Anatomy demonstrated
7. Special considerations

B. Common Errors

NOTE: Show one radiograph of each procedure, progressing from humerus through clavicle. Choose radiographs that demonstrate probable incorrect procedures for each position so that several factors will be discussed.

1. Film handling
2. Positioning
3. Central ray
4. Secondary factors of exposure

C. Questions from students

III. SUMMARY (5 min)

A. Review of Main Points

1. The normal radiograph
2. Common errors

B. Closing Statement: When a repeat study is necessary, analyse the original radiograph and take the necessary measures to correct the errors.

959

SFC JIMMIE BINKLEY
*LP 38-520-040
076

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE & SURGERY
X-RAY BRANCH

Positioning of the Lower Extremity: Foot (1 hour)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES:

TM-280, pp 10-30 through 10-32.
Merrill, Vinita. Atlas of Roentgenographic Positions. 3d ed. Vol. I. St. Louis: C. V. Mosby Company, 1967, pp 70-77.

STUDY ASSIGNMENT: After class study GR 38-520-027-1A and TM 8-280, pp 10-30 through 10-32.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 and GR 38-520-027-1A

TOOLS, EQUIPMENT, AND MATERIALS: GR 38-520-027-1A issued at beginning of sixth week.

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Chalk, chalkboard, and eraser; PA system with lapel mike; Radiographs of the Foot, pointer, and X-ray illuminator (see Annexes A through C)

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

I. INTRODUCTION (2 Min)

A. Opening Statement: The human foot can be described as an archtype of structural design. The shape of the bones and the way in which they are jointed allow for distribution of body weight with minimum stress. Because of this special design, demonstration of the bones of the foot requires a special technique for part of which an angled central ray must be used. X-rays of the feet are accomplished to demonstrate everything from fractures to fallen arches, and you, the X-ray Specialist, will find this examination a part of your daily routine.

---

*This lesson plan supersedes LP 38-520-040, 023.

B. Objectives

1. Identify by name the position and anatomical structures demonstrated of the routine and additional views of the foot.

2. State the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization, film identification and captioning necessary to demonstrate the position(s) of the routine and additional views of the foot.

3. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiograph(s) of the routine and additional views of the foot.

C. Class Procedure and Lesson Tie-in

1. Students will gather around the X-ray table during the demonstration.

2. Students will demonstrate these positions in their laboratory practical exercise on crucial objectives.

II. DEMONSTRATION (40 min)

A. Anatomical structures demonstrated - Foot

NOTE: Place radiographs on viewbox and point out the following anatomical structures.

1. Tarsal Bones (seven)

a. Talus (astragalus)

b. Os Calcis (calcaneus)

c. Navicular (scaphoid)

d. First Cuneiform

e. Second Cuneiform

f. Third Cuneiform

g. Cuboid

2. Metatarsal bones (five)
    a. First Metatarsal
    b. Second Metatarsal
    c. Third Metatarsal
    d. Fourth Metatarsal
    e. Fifth Metatarsal
3. Phalanges (14)
    a. Proximal Row
    b. Middle Row
    c. Distal Row

QUESTION: Name the seven tarsal bones.

ANSWER: Os Calcis; talus; navicular; first, second, and third cuneiform; and cuboid.

B. Positions

NOTE: Refer to Annex A through C for explanation of positions and have the students fill in their GR's.

1. Dorso-Plantar (routine)

QUESTION: What is the part-to-film holder reference for the dorsoplanatar foot?

ANSWER: Greater toe 2 inches below the upper film border.

2. Oblique (routine)
3. Lateral (additional)

QUESTION: What is the degree and direction of rotation for the oblique foot?

ANSWER: 45 degrees, medial rotation.

NOTE: Emphasize that the foot routine demonstrates the march fracture.

C. Demonstrate Positions Using Information in Annex A through C.

NOTE: Positions will be demonstrated by the instructor, using a student from the class as a patient and refer students to the order of procedure.

NOTE: Emphasize that all obliques of the lower extremity are rotated inward.

D. Questions from Students

NOTE: Make Study Assignments: After class study TM 8-280, p 10-30 through 10-32 and GR 38-520-027-1A.

III. SUMMARY (3 min)

A. Review of Main Points

1. Anatomical Structures

2. Positions

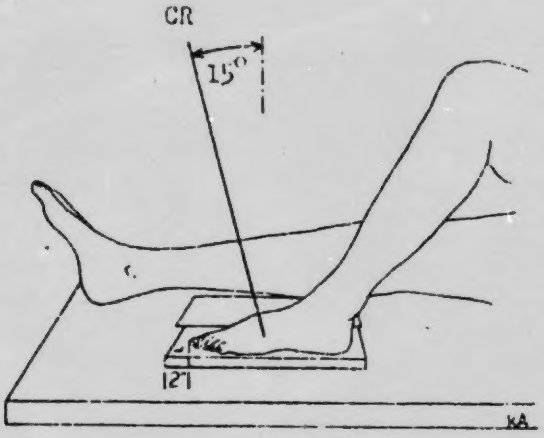
3. Demonstration

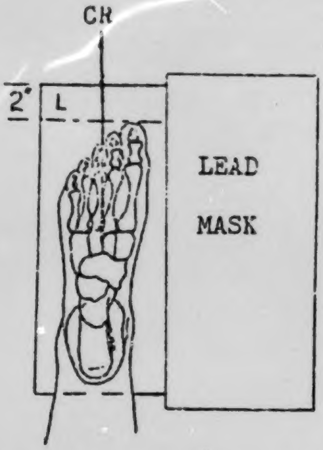
B. Closing Statement: As a military X-ray specialist you will be radiographing the foot routinely for Trauma and Pathology. Because the feet are essential for mobility, it will be up to you, the X-ray specialist, to perform these exams and consistently produce diagnostic radiographs.

Foot

Routine: Dorso-Plantar and Oblique

Additional: Lateral





Foot Position Dorso-Plantar

PFR: Great Toe 2" below the upper film border

Film Rundown: 10 x 12, LW, NB CR: 15° Cephalic Cone: FFC

Alignment: Part centered with sole of foot firmly in contact with film holder.

Demonstrates: Distal Tarsals, Metatarsals and Phalanges

Notes: FFD: 40" ID: Above digits reading down

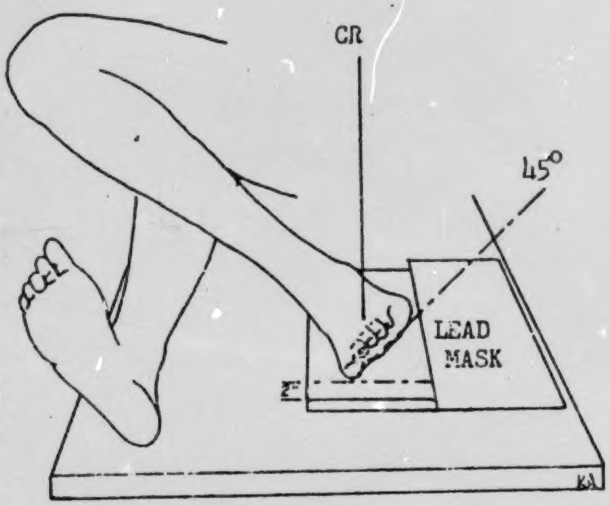
1. IMMOBILIZATION: Patient may hold knee to aid in immobilization.
2. The shoe and sock are removed.
3. A drape sheet is used if necessary.
4. Emphasize that the foot routine demonstrates the March Fracture.

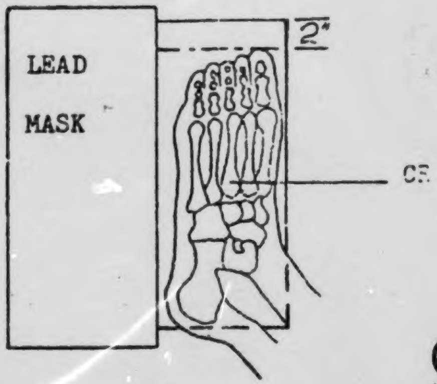
ANNEX B
INSTRUCTIONAL AIDS

Foot

Routine: Dorso-Plantar and Oblique

Additional: Lateral





Foot Position Oblique

PFR: Great Toe 2" below upper film border

Film Rundown: 10 x 12, LW, NB CR: V.P. Cone: FFC

Alignment: Part centered. Foot and leg rotated medially until the Plantar surface of the foot is 45° to the surface of the film.

Demonstrates: Tarsals, Metatarsals and Phalanges

Notes: FFD: 40" ID: Above digits reading down

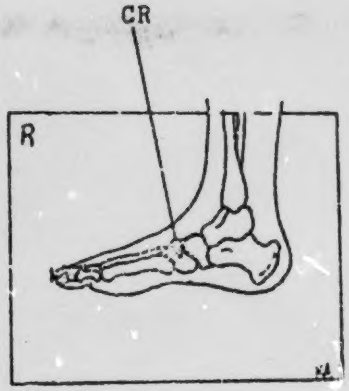
1. IMMOBILIZATION: Place sand bag beneath leg or support the knee of the side under study with the opposite knee and have the patient grasp the edge of the table.

2. Oblique View: Have the leg extend off lateral border of the film holder.

Foot

Routine: Dorso-Plantar and Oblique

Additional: Lateral



Foot Position Lateral

PFR: Transverse plane through the midlongitudinal arch to the center of the film holder

Film Rundown: 10 x 12, LW, NB CR: VP Cone: FFC

Alignment: Part centered and plantar surface of the foot perpendicular to the film holder.

Demonstrates: Foreign body localization or placement of fragments in fractures.

Notes: FFD: 40" ID: Above part reading down.

1. IMMOBILIZATION: Place sand bag across leg.

2. VARIATION: Weight bearing laterals of both feet may also be taken to determine the condition of the longitudinal arch. Patient is standing with the weight of the body equally distributed on both feet. CR is HP.

3. Shoes and socks removed.

SFC JIMMIE BINKLEY

ACADEMY OF HEALTH SCIENCES, US ARMY *LP 38-520-042
DIVISION OF MEDICINE & SURGERY 076
X-RAY BRANCH

Positioning of the Lower Extremity: Os Calcis (1 hour)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES:

TM 8-280, pp 10-36.
Merrill, Vinita. Atlas of Roentgenographic Position. 3d ed Vol I St. Louis: C. V. Mosby Company, 1967, p 80

STUDY ASSIGNMENT: After class study GR 38-520-027-1A and TM 8-280, pp 10-36.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 and GR 38-520-027-1A.

TOOLS, EQUIPMENT, AND MATERIALS: GR 38-520-027-1A issued at beginning of sixth week.

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Chalkboard, chalk, and eraser; Radiographs of the os calcis, pointer and X-ray illuminator; PA system with lapel mike (see Annexes A and B)

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

I. INTRODUCTION (2 min)

A. Opening Statement: In Greek mythology, the mother of Achilles made him invulnerable by dipping him in the River Styx. Thus, he became the bravest soldier of the Greek Army. While dipping him, however, his mother did not submerge the tip of his heel, known today as Achilles tendon. Therefore, during the siege of Troy, an arrow struck Achilles in the only vulnerable spot, his heel, known to us as the "os calcis." In the Army, injuries to the area of the foot are exceptionally common. This area includes the os calcis and, therefore, necessitates complete knowledge of the routine os calcis.

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*This lesson plan supersedes LP 38-520-042, 033.

B. Objectives

1. Identify by name the position and anatomical structures demonstrated of the routine views of the os calcis.

2. State the correct routine, PFR/CRPR, film rundown, cone-field, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization, film identification and captioning necessary to demonstrate the position(s) of the routine views of the os calcis.

3. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment, and the correct positioning data which would produce a technically acceptable radiograph(s) of the routine views of the os calcis.

C. Class Procedure and Lesson Tie-in

1. Students will gather around the X-ray table during the demonstration.

2. Students will demonstrate these positions in their laboratory practical exercise on crucial objectives.

II. DEMONSTRATION (40 min)

A. Anatomical Structures Demonstrated - Os Calcis

NOTE: Place radiographs on viewbox and point out the following anatomical structures:

1. Distal leg

   a. Tibia

   b. Fibula

2. Tarsal bones

   a. Os calcis

   b. Talus

   c. Navicular

QUESTION: What is the largest of the tarsal bones?

ANSWER: Os calcis.

B. Positions

NOTE: Refer to Annexes A and B for explanation of positions and have students fill in their GR's.

1. Inferior-Superior (routine)

QUESTION: What is the angle and direction of the central ray?

ANSWER: 40° cephalic.

2. Lateral (routine)

QUESTION: What is the angle and direction of the central ray?

ANSWER: Perpendicular.

C. Demonstrate positions using information in Annexes A and B.

NOTE: Positions will be demonstrated by the instructor using a student from the class as a patient and refer students to the order of procedure.

NOTE: Immobilize foot with belt or towel.

NOTE: It will be necessary to elevate the tube from its position used for the inferior-superior to attain the proper FFD.

NOTE: Foot will extend off the lateral border of the film.

D. Questions from Students.

NOTE: Make study assignment: After class study GR 38-520-027-1A and TM 8-280, pp 10-36.

III. SUMMARY (3 min)

A. Review of Main Points

1. Anatomical Structures

2. Positions

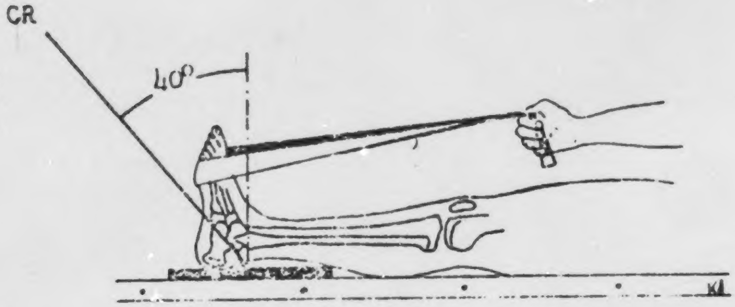
3. Demonstration

B. Closing Statement: In order for a human being to be stable on his feet, the os calcis must be in good repair. The best way to help repair a fractured os calcis is to initially obtain good diagnostic radiographs. So, do not let the os calcis be your "Achilles Heel" in radiographic procedures.

ANNEX A
INSTRUCTIONAL AIDS

Os Calcis

Routine: Infero-Superior and Lateral



Os Calcis Position Infero-Superior

PFR: Midmalleoler plane to center of the film holder

Film Rundown: 10 x 12, CW, NB CR: 40° Ceph Cone: FFC

Alignment: Part centered with epicondyles parellel to table and plantar surface of the foot perpendicular to the film holder.

Demonstrates: Os Calcis, Malleoli and soft tissues

Notes: FFD: 40" ID: On the lateral border or below the lateral view.

1. IMMOBILIZATION: Use belt-type traction on foot.

2. Patient is instructed to pull belt-type traction till plantar surface of the foot is perpendicular to the film.

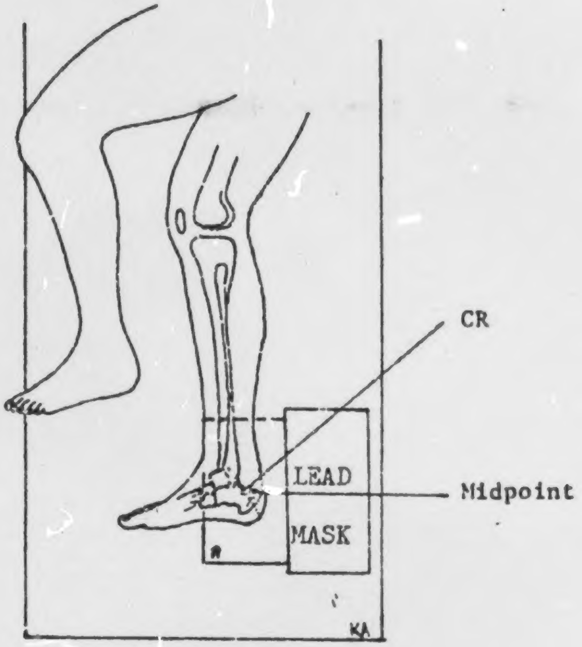
3. Shoe and sock are removed.

971

INSTRUCTIONAL AIDS

Os Calcis

Routine: Infero-Superior and Lateral



Os Calcis Position Lateral .

PFR: Midpoint of a line between the medial malleolus and the apex of the heel to the center of the film holder.

Film Rundown: 10 x 12, CW, NB CR: VP Cone: FFC

Alignment: Part centered, Epicondyles perpendicular to the table, foot and leg form a 90° angle.

Demonstrates: Os Calcis

Notes: FFD: 40" ID: On the lateral border or below the lateral view.

1. IMMOBILIZATION: Place sand bag against toes.

2. Lateral view is done first. Foot must extend off the lateral border of the film holder.

971

SFC JIMMIE BINKLEY

ACADEMY OF HEALTH SCIENCES, US ARMY *LP 38-520-041
DIVISION OF MEDICINE & SURGERY 076
X-RAY BRANCH

Positioning of the Lower Extremity: Ankle (1 hour)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES:

TM 8-280, pp 10-33 through 10-35.
Merrill, Vinita. Atlas of Roentgenographic Positions. 3d ed, Vol I. St. Louis: C. V. Mosby Company, 1967, pp 88-91.

STUDY ASSIGNMENT: After class study GR 38-520-027-1A and TM 8-280, pp 10-33 through 10-35.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 and GR 38-520-027-1A

TOOLS, EQUIPMENT, AND MATERIALS: GR 38-520-027-1A issued at beginning of sixth week.

PERSONNEL: One instructor (MOS 91P2H or 91P4H).

INSTRUCTIONAL AIDS: Chalk, chalkboard, and eraser; PA system with lapel mike; Radiographs of the ankle, pointer, and X-ray illuminator (See Annexes A through C)

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

I. INTRODUCTION (2 min)

A. Opening Statement: When a dog injures a paw, he instinctively learns to walk on three legs to allow the injured part to rest. Man, being a biped, is at a much greater disadvantage. A sprain or fracture of the ankle results in his having to depend on artificial support such as a walking cast or crutches until the injury heals. The X-ray specialist is required to take the original radiographs for diagnosis as well as the follow-up films which the doctor uses to determine the progress of healing.

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*This lesson plan supersedes LP 38-520-041, 033

B. Objectives

1. Identify by name the position and anatomical structures demonstrated of the routine views of the ankle

2. State the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization, film identification and captioning necessary to demonstrate the position(s) of the routine views of the ankle.

3. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment, and the correct positioning data which would produce a technically acceptable radiograph(s) of the routine views of the ankle.

C. Class Procedure and Lesson Tie-in

1. Students will gather around the X-ray table during the demonstration.

2. Students will demonstrate these positions in their laboratory practical exercise on crucial objectives.

II. DEMONSTRATION (40 min)

A. Anatomical Structures Demonstrated - Ankle

NOTE: Place radiographs on the viewbox and point out the following anatomical structures.

1. Tarsal Bones
   - a. Talus
   - b. Os calcis
   - c. Navicular
   - d. Cuboid
   - e. First cuneiform
   - f. Second cuneiform
   - g. Third cuneiform

974

2. Articulations

a. Ankle mortise

b. Distal tibiofibular

3. Distal leg

a. Tibia

b. Fibula

QUESTION: What three bones make up the ankle joint?

ANSWER: (1) Tibia, (2) Fibula, (3) Talus.

B. Positions

NOTE: Refer to Annexes A through C for explanation of positions and have the students fill in their GR's.

1. AP (routine)

QUESTION: What is the PFR for the AP view?

ANSWER: Midpoint between malleoli to center of film holder.

2. Oblique (routine)

3. Lateral (routine)

NOTE: Emphasize that the ankle routine demonstrates the Pott's Fracture.

C. Demonstrate Positions Using Information in Annex A through C.

NOTE: Positions will be demonstrated by the instructor, using a student from the class as a patient and refer students to the order of procedure.

NOTE: In the AP view, the epicondyles of the femur are parrallel to the film, and on the lateral view they are perpendicular.

NOTE: In the oblique view the foot and leg are both rotated 45 degrees medially.

D. Questions from Students

NOTE: Make Study Assignment: After class study GR 38-520-027-1A and TM 8-280, pp 10-33 through 10-35.

974

III. SUMMARY (3 min)

A. Review of Main Points

1. Anatomical Structures

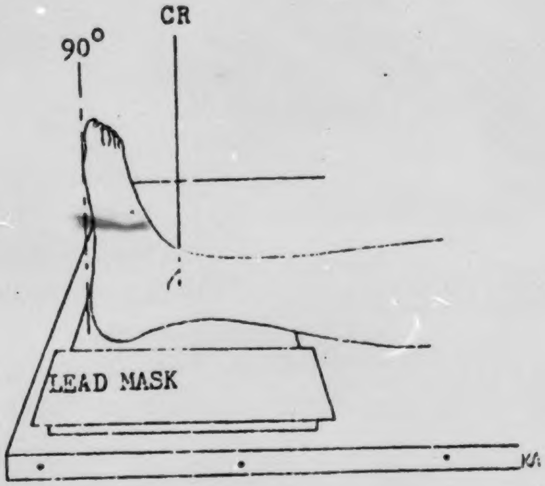
2. Positions

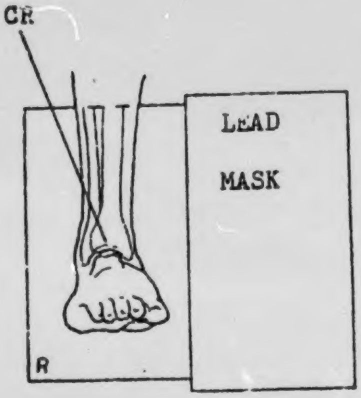
3. Demonstration

B. Closing Statement: Since fractures of the ankle usually involve a long, painful, recovery period, it is imperative that the X-ray specialist be capable of producing highly diagnostic radiographs of the ankle to minimize patient discomfort and a long healing period.

Ankle

Routine: AP, Oblique and Lateral





Ankle Position AP

PFR: Midpoint between malleoli to center of film holder

Film Rundown: 10 x 12, CW. NB CR: VP Cone: FFC

Alignment: Part centered and epicondyles parallel to the table

Demonstrates: Talus, Distal Tibia and Fibula and Ankle joint

Notes: FFD: 40" ID: Either lateral border

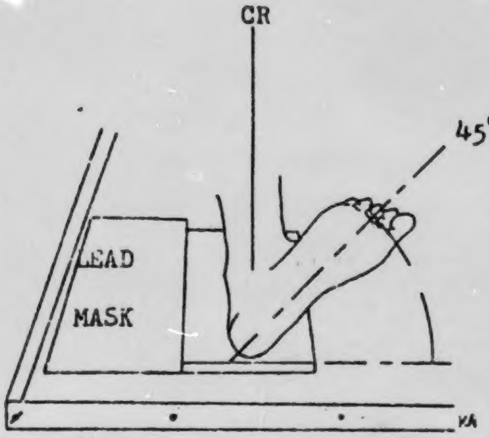
1. IMMOBILIZATION: Place sand bag against sole of foot.
2. Plantar surface of the foot perpendicular to the film.
3. Shoes and socks are removed.

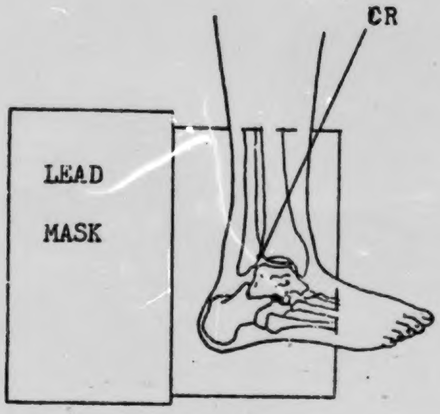
TM 8-280 pp. 10-33 Figure 10-28

ANNEX B
INSTRUCTIONAL AIDS

Ankle

Routine: AP, Oblique and Lateral





Ankle Position Oblique

FFR: Midpoint between malleoli to the center of the film holder

Film Rundown: 10 x 12, CW, NB CR: VP Cone: FFC

Alignment: Part centered with the foot and leg rotated 45° medially

Demonstrates: Distal Tibiofibular articulation, lateral malleolus and ankle joint

Notes: FFD: 40" ID: Either lateral border

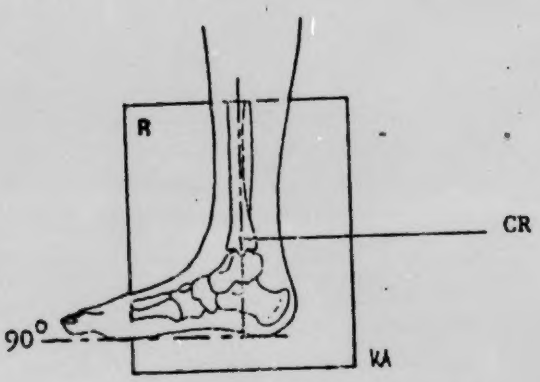
1. IMMOBILIZATION: Rest toes against sand bag
2. Plantar surface of the foot perpendicular to the film.
3. Take oblique first. Foot extends off the lateral film border with toes resting on a sand bag.

TM 8-280 pp. 10-34 Figure 10-29

ANNEX C
INSTRUCTIONAL AIDS

Ankle

Routine: AP, Oblique and Lateral



Ankle Position Lateral

PFR: Malleolar plane (Medial Malleolus) to the center of the film

Film Rundown: 8 x 10, LW, NB CR: VP Cone: FFC

Alignment: Part centered, Epicondyles perpendicular to the table. Foot and leg form a 90° angle.

Demonstrates: Distal Tibia and Fibula, Talotibial articulation and Tarsals.

Notes: FFD: 40" ID: Either lateral border

1. IMMOBILIZATION: Place sand bag against toes.

2. For lateral views of the lower extremity, patient is always laterally recumbant with the lateral side of the effected extremity next to the film.

TM 8-280 p. 10-35 Figure 10-30

978

SFC JIMMIE BINKLEY
*LP 38-520-045
076

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

Positioning of the Lower Extremity: Leg (1 hour)

COURSES PRESENTED TO: Radiographic Procedures (Basic), 313-91P20

PLACE: Classroom

REFERENCES:

TM 8-280, pp 10-37 and 10-38.
Merrill, Vinita. Atlas of Roentgenographic Positions. 3d ed. Vol. I. St. Louis: C.V. Mosby Company, 1967, pp 92-93.

STUDY ASSIGNMENT: After class study GR 38-520-027-1A and TM 8-280, pp 10-37 and 10-38.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 and GR 38-520-027-1A.

TOOLS, EQUIPMENT, AND MATERIALS: GR 38-520-027-1A issued at beginning of sixth week

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Chalk, chalkboard, and eraser; PA system with lapel mike; Radiographs of the leg, pointer, and x-ray illuminator (see Annexes A and B)

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

I. INTRODUCTION (2 min)

A. Opening Statement: The strength and permanence of a building is primarily dependent upon the condition of its foundation supports. Likewise, the human skeleton needs strong and dependable supports to provide stability for the body. This support is the legs, and just as a crack in the supports of a building will weaken the entire structure, an injury to the legs will hinder the performance of the human body.

B. Objectives

1. Identify by name the position and anatomical structures

980

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*This lesson plan supersedes LP 38-520-045, 074.

demonstrated of the routine views of the proximal and distal leg.

2. State the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization, film identification and captioning necessary to demonstrate the position(s) of the routine views of the distal and proximal legs.

3. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiograph(s) of the routine views of the distal and proximal femur.

C. Class Procedure and Lesson Tie-in

1. Students will gather around the x-ray table during the demonstration.

2. Students will demonstrate these positions in their laboratory practical exercise on crucial objectives.

II. DEMONSTRATION (40 min)

A. Anatomical Structures Demonstrated — Leg

NOTE: Place radiographs on the viewbox and point out the following anatomical structures.

1. Tibia

a. Proximal

(1) Intercondyloid Eminence

(2) Medial condyloid facet

(3) Medial condyle

(4) Tibial tuberosity

b. Distal

(1) Medial malleolus

(2) Inferior articular surface

2. Fibula

a. Proximal

(1) Head

(2) Styloid process

b. Distal lateral malleolus

3. Shaft

4. Patella

5. Distal femur

6. Talus

NOTE: Emphasize that the tibia and fibula are long bones.

QUESTION: In which portion of the leg is the tibia located?

ANSWER: Medial.

B. Positions

NOTE: Refer to Annexes A and B for explanation of positions and have students fill in their GR's.

1. AP and lateral (distal — routine)

2. AP and lateral (proximal — routine)

QUESTION: What is the PFR for the proximal leg?

ANSWER: Apex (inferior border) of the patella 3 inches below upper film border.

NOTE: Stress that all long bones must include one joint. The joint nearest the site of injury will be included on all views of the routine.

NOTE: Emphasize that the distal leg demonstrates the Pott's Fracture.

NOTE: Emphasize that all long bones are positioned so that the length of the bone is placed to the length of the film.

C. Demonstrate positions using information in Annexes A & B.

NOTE: Positions will be demonstrated by the instructor using a student from the class as a patient and refer students to the order of procedure.

981

LP 38-520-045
076

NOTE: Demonstrate the lateral first and emphasize that the foot extends off the lateral border in both the proximal and distal routines.

NOTE: Stress that the epicondyles are parallel to the film for the AP view and perpendicular for the lateral view.

D. Questions From Students

NOTE: Make study assignment: After class study GR 38-520-027-1A and TM 8-280, pp 10-37 and 10-38.

III. SUMMARY (3 min)

A. Review of Main Points

1. Anatomical Structures

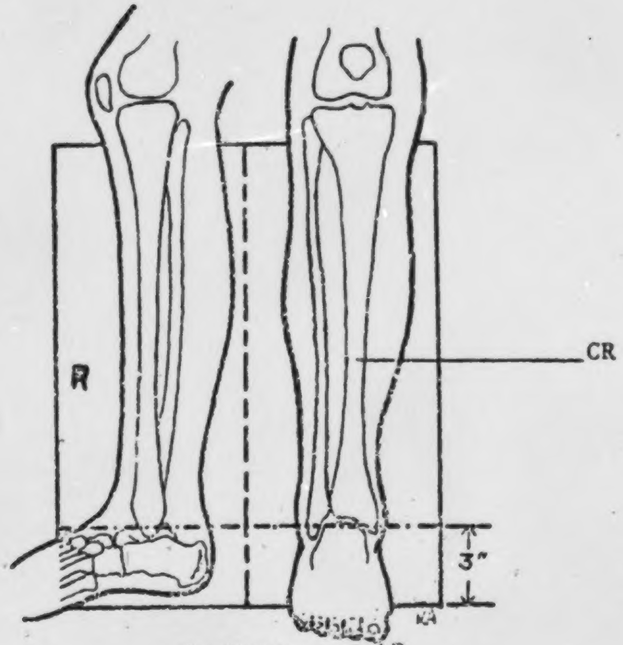
2. Positions

3. Demonstration

B. Closing Statement: The legs provide mobility and support to our skeletal system. Injuries to the legs require immediate medical attention which includes routine radiographs. It will be your responsibility to provide these radiographs both quickly and precisely.

Leg

Routine: AP and Lateral Distal Leg



Position Lateral, Position AP

PFR: Malleoli 3" above the lower film border

Film Rundown: 14 x 17. LW, NB CR: VP Cone: FFC

Alignment: Part centered. (AP) Epicondyles parallel to the film.

(Lateral) Epicondyles perpendicular to the film.

Demonstrates: Ankle joint and lower 2/3 of the Tibia and Fibula.

Notes: FFD: 40" ID: Either lateral border

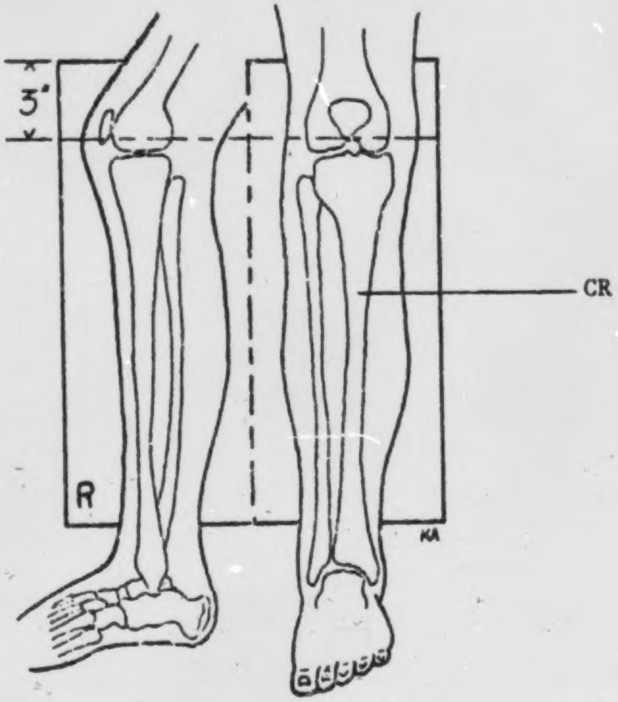
1. IMMOBILIZATION: Place sandbag against toes and the plantar surface of the foot.
2. Shoe and sock are removed. Use drape sheet if necessary.
3. The lateral view extends off the lateral border of the film border.
4. The distal leg routine best demonstrates Potts Fracture.

TM 8-280 pp. 10 37-38 Figure 10 32 & 33

ANNEX B
INSTRUCTIONAL AIDS

Leg

Routine: AP and Lateral Proximal Leg



Position Lateral Position AP

PFR: Apex of the Patella 3" below the upper film border.

Film rundown: 14 x 17, LW, NB CR: VP Cone: FFC

Alignment: Part Centered. (AP) Epicondyles parallel to the film

(Lateral) Epicondyles perpendicular to the film.

Demonstrates : Knee joint and the proximal 2/3 of the Tibia and Fibula.

Notes: FFD 40" ID: Either lateral border

1. IMMOBILIZATION: Place sandbag against the toes and plantar surface of the foot.
2. The shoe and sock are removed. Use drape sheet if necessary
3. Lateral view extends off the lateral border of the film holder.

SFC JIMMIE BINKLEY

ACADEMY OF HEALTH SCIENCES, US ARMY *LP 38-520-043
DIVISION OF MEDICINE & SURGERY 076
X-RAY BRANCH

Positioning of the Lower Extremity: Knee (1 hour)

COURSES PRESENTED TO: Radiographic Procedures (Basic), 313-91P20

PLACE: Classroom

REFERENCES:

TM 8-280, pp 10-39 through 10-41.
Merrill, Vinita. Atlas of Roentgenographic Positions. 3d ed, Vol I, St. Louis: C. V. Mosby Co., 1967, pp 94-96.

STUDY ASSIGNMENT: After class study GR 38-520-027-1A and TM 8-280, pp 10-39 through 10-41.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 and GR 38-520-027-1A

TOOLS, EQUIPMENT, AND MATERIALS: GR 38-520-027-1A issued at beginning of sixth week.

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Chalk, chalkboard, and eraser; PA system with lapel mike; Radiographs of the knee, pointer and X-ray illuminator (see Annexes A through C.

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

I. INTRODUCTION (2 min)

A. Opening Statement: One of the most common sites of injury to the human body is the area of the knee. Knee injuries are very common in the military, and a long and painful recovery period may be shortened by competent early radiographic diagnosis. Therefore, each of you, as X-ray specialists, must be capable of contributing to the physical well-being of the patient through a sound knowledge and application of proper radiographic procedures.

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*This lesson plan supersedes LP 38-520-043, 074

985

B. Objectives

1. Identify by name the position and anatomical structures demonstrated of the routine and additional views of the knee.

2. State the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization, film identification and captioning necessary to demonstrate the position(s) of the routine and additional views of the knee.

3. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiograph(s) of the routine and additional views of the knee.

C. Class Procedure and Lesson Tie-in

1. Students will gather around the X-ray table during the demonstration.

2. Students will demonstrate these positions in their laboratory practical exercise on crucial objectives.

II. DEMONSTRATION (40 min)

A. Anatomical Structures Demonstrated - Knee.

NOTE: Place radiographs on the viewbox and point out the following anatomical structures:

1. Proximal tibia and fibula
    a. Medial condyle of tibia
    b. Lateral condyle of tibia
    c. Tibial tuberosity
    d. Intercondyloid eminence
    e. Head and neck of fibula
2. Patella
    a. Superior border
    b. Apex

987

NOTE: Instructor emphasize that the patella is the largest sesamoid bone in the body.

3. Distal femur
    a. Medial epicondyle
    b. Lateral epicondyle
    c. Intercondylar notch

QUESTION: The intercondyloid eminence is a part of what bone?

ANSWER: Tibia.

B. Positions

NOTE: Refer to Annexes A through C for explanation of positions and have students fill in their GR's.

1. AP (routine)
2. Lateral (routine)
3. PA (additional)

C. Demonstrate positions using information in Annexes A through C.

NOTE: Positions will be demonstrated by the instructor using a student from the class as a patient and refer students to the order of procedure.

NOTE: Emphasize that the epicondyles are parallel to the film on AP view.

QUESTION: What is the PFR for the AP knee?

ANSWER: Apex (inferior border) of patella to center.

NOTE: Stress that the femur extends in from the upper border.

QUESTION: How are the epicondyles aligned to the film on the lateral position?

ANSWER: Perpendicular to the film.

NOTE: PA knee demonstrates the patella.

D. Questions from Students

NOTE: Make study assignment: After class study GR 38-520-027-1A and TM 8-280, pp 10-39 through 10-41.

987

III. SUMMARY (3 min)

A. Review of Main points

1. Anatomical Structures

2. Positions

3. Demonstration

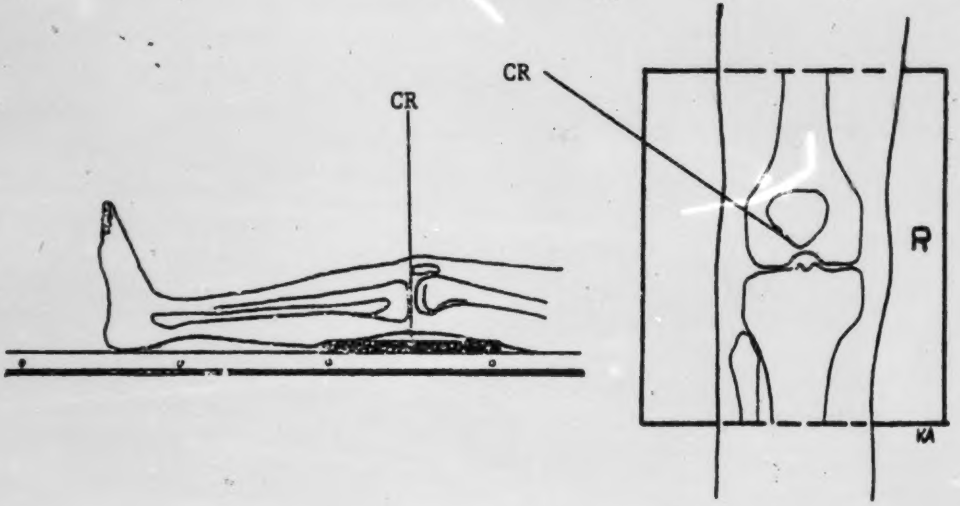
B. Closing Statement: Knee injuries are very common in the military. It is necessary that the Army X-ray specialist have a sound understanding of the positioning of the knee, especially care and handling in cases of known trauma and pathology.

989

ANNEX A
INSTRUCTIONAL AIDS
Knee

Routine: AP and Lateral

Additional : PA



Knee Position AP

PFR: Apex of Patella to center of film holder

Film rundown: 8 x 10, LW, NB CR: VP Cone: FFC

Alignment: Part centered. Leg in full extension with Epicondyles parallel to the film.

Demonstrates: Distal femur, proximal tibia and fibula and the interspace.

Notes: FFD 40" ID: Either lateral border

1. IMMOBILIZATION: Place sandbags on each side of the foot.
2. To show maximum joint space angle the CR 10° Cephalic to the center of the film.

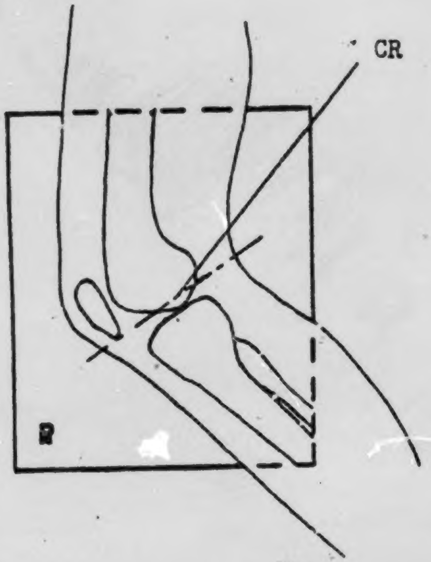
TM 8-280 pp. 10-39 Figure 10-34

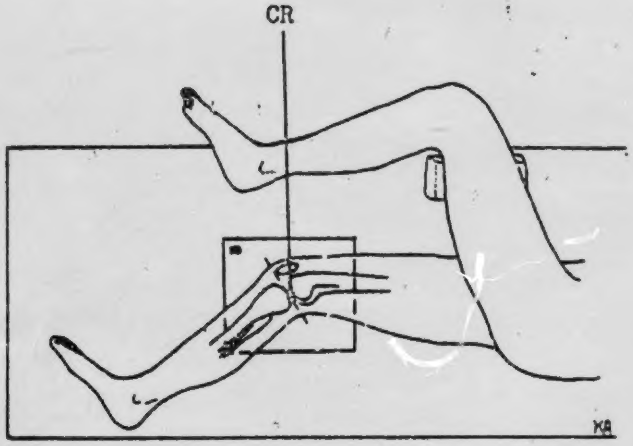
LP 38-520-043 989
076

ANNEX B
INSTRUCTIONAL AIDS
Knee

Routine: AP and Lateral

Additional: PA





Knee **Position** Lateral

PFR: Midpoint of a line between the apex of the patella and the posterior surface of the knee to the center of the film holder.

Film Rundown: 8 x 10, LW, NB **CR:** VP **Cone:** FFC

Alignment: Part centered. Epicondyles perpendicular to the film and knee flexed approximately 45°.

Demonstrates: Lateral view of the distal femur, proximal tibia and fibula, patella and the interspace.

Notes: FFD: 40" ID: Lateral border, anterior to part

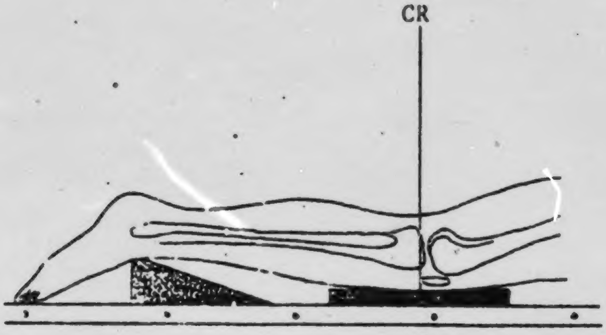
1. IMMOBILIZATION: Place sandbags across lower leg.
2. Patient laterally recumbant with the unaffected leg crossed over and out of the way.

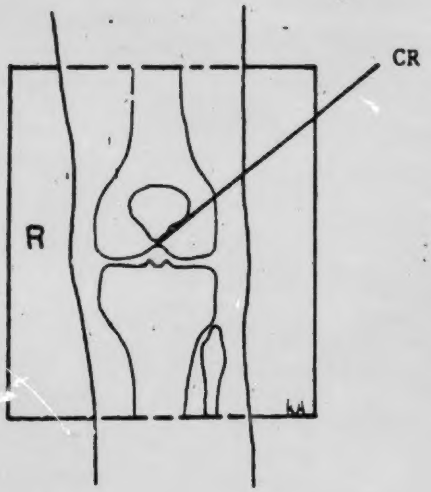
TM 8-280 pp. 10-41 Figure 10-36

Knee

Routine: AP and Lateral

Additional: PA





Knee Position PA

PPR: Apex of patella to center of film holder

Film rundown: 8 x 10, LW, NB CR: VP Cone: FFC

Alignment: Part centered. Leg in full extension with Epicondyles parallel to the film

Demonstrates: Patella, distal femur, proximal tibia and fibula

Notes: FFD 40" ID: Either lateral border

1. IMMOBILIZATION: Place sponge block under ankle and have toes extending off table. This also aids in patient comfort.

2. This view is taken primarily for better visualization of the patella.

ACADEMY OF HEALTH SCIENCES, US ARMY LP 38-520-073
DIVISION OF MEDICINE AND SURGERY 126
X-RAY BRANCH

Errata Sheet No 1

Positioning: Knee (Holmblad and Beclere (1 hour)

LP 38-520-073, 076, is changed as follows:

A. Change Objectives to read:

1. Identify by name the position and anatomical structures demonstrated of the Holmblad and Beclere views of the knee.

2. Determine the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization, film identification and captioning necessary to demonstrate the position(s) of the Holmblad and Beclere views of the knee.

3. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiographic position(s) of the Holmblad and Beclere views of the knee.

B. Change Positions to read:

NOTE: Refer to Annexes A and B for explanation of positions and have students fill in their GR's

1. Holmblad - PA

NOTE: Emphasize restricting conefield to 6 inches, using correct marker in field.

QUESTION: What is the alignment for a Holmblad knee?

ANSWER: Epicondyles are parallel to film and the thigh and leg form a 110 degree angle (thigh is 70 degrees with table).

2. Beclere knee - AP

NOTE: Emphasize that the Holmblad knee position is performed PA, using a PFR, while Beclere is AP, using a CRPR. Additionally, Holmblad film position lengthwise and Beclere crosswise. Explain purpose of the turn of film holder.

NOTE: Emphasize restricting conefield to 6 inches, using correct marker in field.

992

NOTE: Patient is supine or seated on table with the affected knee flexed. The film is parallel to the table and built up with sandbags.

NOTE: This view is taken only when the patient is unable to assume the Holmblad position.

QUESTION: What is the angle and direction of the CR for the Beclere knee?

ANSWER: The CR is perpendicular to leg and cephalic.

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*LP 38-520-073
076

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

Positioning: Knee (Holmblad and Beclere) 1 hour

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES:

TM 8-280, pp 10-42.
Merrill, Vinita. Atlas of Radiographic Positions. 3d ed, Vol. I. St. Louis, Missouri: C.V. Mosby Company, 1967, pp 98-101.

STUDY ASSIGNMENT: After class study study GR 38-520-027-1A and TM 8-280, pp 10-42.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 and GR 38-520-027-1

TOOLS, EQUIPMENT, AND MATERIALS: GR 38-520-027-1 issued at beginning of the sixth week

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Chalk, chalkboard, and eraser; PA system with lapel mike; Radiographs of the Halmblad and Beclere knee, pointer and x-ray illuminator (see Annexes A and B)

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

I. INTRODUCTION (5 min)

A. Opening Statement: There is no injury more feared by parents or coaches than a knee injury received in or out of the military when participating in sports. This injury may not be a fracture, but one that involves ligaments and muscles. Therefore, special views must be taken. Such special views require specific angles and exact positioning. Extreme care must be used in positioning to avoid undue discomfort or further injury to the patient.

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*This lesson plan supersedes LP 38-520-0730, 094.

B. Objectives

1. Identify by name the position and anatomical structures demonstrated of the Holmblad and Beclere views of the knee.

2. State the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization, film identification and captioning necessary to demonstrate the position(s) of the Holmblad and Beclere views of the knee.

3. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiograph(s) of the Holmblad and Beclere views of the knee.

C. Class Procedure and Lesson Tie-in

1. Students will gather around the x-ray table during the demonstration.

2. Students will demonstrate these positions in their laboratory practical exercise on crucial objectives.

II. DEMONSTRATION (35 min)

A. Anatomical Structures Demonstrated -- Knee

NOTE: Place radiographs on viewbox and point out the following anatomical structures.

1. Femur
2. Femoral epicondyles
3. Tibia
4. Intercondyloid fossa
5. Intercondyloid eminence (tibial spine)

B. Positions

NOTE: Refer to Annexes A and B for explanation of positions and have students fill in their GR's.

NOTE: Emphasize restricting conefield to 6 inches, using correct marker in field.

995

QUESTION: What is the alignment for a Holmblad knee?

ANSWER: Epicondyles are parallel to film and the thigh and leg form a 110 degree angle (thigh is 70 degrees with table).

2. Beclere knee - AP

NOTE: Emphasize that the Holmblad knee position is performed PA, using a PFR, while Beclere is AP, using a CRPR. Additionally, Holmblad film position lengthwise and Beclere crosswise. Explain purpose of the turn of film holder.

NOTE: Emphasize restricting conefield to 6 inches, using correct marker in field.

NOTE: Patient is supine or seated on table with the affected knee flexed. The film is parallel to the table and built up with sandbags.

NOTE: This view is taken only when the patient is unable to assume the Holmblad position.

QUESTION: What is the angle and direction of the CR for the Beclere knee?

ANSWER: The CR is perpendicular to leg and cephalic.

C. Demonstrate positions using information in Annexes A and B.

NOTE: Positions will be demonstrated by the instructor, using a student from the class as a patient and refer students to the order of procedure.

D. Questions from Students

NOTE: Make study assignment: After class study GR 38-520-027-1A and TM 8-280, pp 10-42.

III. SUMMARY (5 min)

A. Review of Main Points

1. Anatomical structures

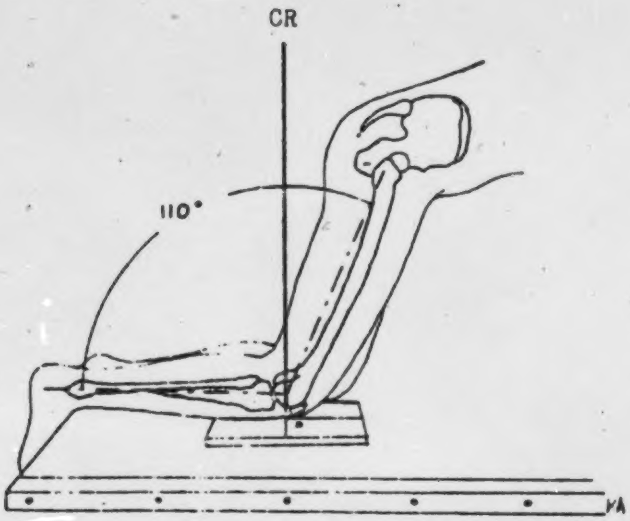
2. Positions

3. Demonstration

B. Closing Statement: Remember, always consider your patient's comfort first. If the Radiologist wishes to see the intercondyloid fossa and eminence, you have the option of taking either the Holmblad or Beclere view, for they both demonstrate the same anatomical structures. So you, the technologist, must take the view that will cause the least amount of discomfort to your patient.

ANNEX A
INSTRUCTIONAL AIDS
Knee

Routine: Holmblad



PFR Knee Position Holmblad

XXXX: Apex of patella to center of film holder.

Film rundown: 8 x 10, LW, NB CR: VP Cone: 6"

Alignment: Part centered, Epicondyles parallel with film holder. Femur and leg form an angle of 110°

Demonstrates: Intercondyloid fossa and intercondyloid eminence

Notes: FFD: 40" ID: Either lateral border in the cone field

1. IMMOBILIZATION: Place sandbags against each side of leg under study.
2. Patient on hands and knees with weight shifted to hands and unaffected knee.
3. Holmblad is the position of choice over Beclare because of less part magnification due to object film distance (OFD)

TM 8-280 pp. 10-42 Figure 10-37

ANNEX B
INSTRUCTIONAL AIDS

Knee

Routine: Beclere

Knee Position Beclere

CRPR: Apex of patella projected to center of film holder.

Film Rundown: 8 x 10, CW, NB CR: Cephalic and perpendicular to tibia Cone: 6"

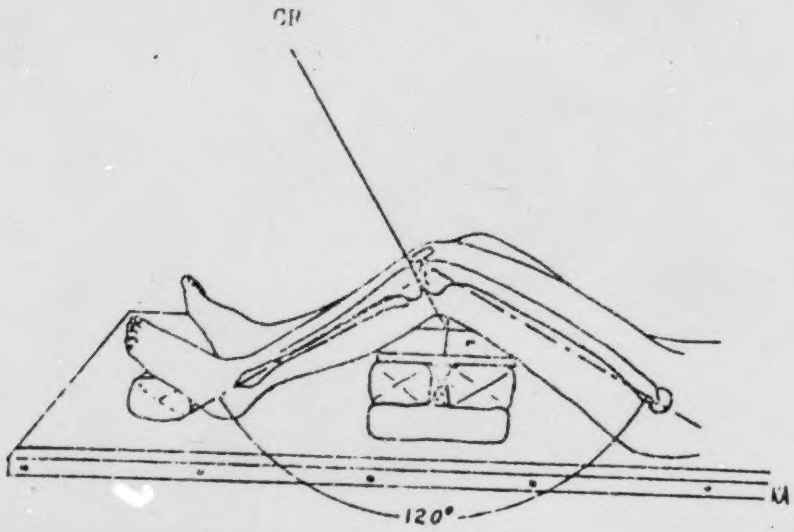
Alignment: Part centered, Epicondyles parallel to film, femur and leg form an angle of 120°

Demonstrates: Intercondyloid fossa and intercondyloid eminence

Notes: FFD: 40" ID: Either lateral border within the conefield

1. IMMOBILIZATION: Place sandbags against each side of the foot and leg under study.
2. The film is positioned parallel to table top and supported on sandbags to bring it in close contact with the posterior aspect of the knee.
3. Do Beclere knee if patient cannot assume the Holmblad position.

TM 8-280 pp. 10-42 Figure 10-37



SFC JIMMIE BINKLEY
*LP 38-520-074
076

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

Positioning: Knee (Settegast) (1 hour)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES:

TM 8-280, pp 10-43.
Merrill, Vinita. Atlas of Roentgenographic Positions. 3d ed. Vol. I. St. Louis, Missouri: C.V. Mosby Company, 1967, pp 104-105.

STUDY ASSIGNMENT: After class study GR 38-520-027-1A and TM 8-280, pp 10-43

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 and GR 38-520-027-1

TOOLS, EQUIPMENT, AND MATERIALS: GR 38-520-027-1A issued at beginning of the sixth week

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Chalk, chalkboard, and eraser; PA system with lapel mike; Radiographs of the Settegast knee, pointer and x-ray illuminator (see Annexes A and B)

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

I. INTRODUCTION (2 min)

A. Opening Statement: The Settegast knee is taken primarily to demonstrate the patella and femoral-patella interspace. We vixualize the patella much like the sun rising in the east. For this reason, the Settegast position is sometimes referred to as the "sunrise position." Along with the many angulations involved and technical factors, the X-Ray Specialist must be exacting in order to do this special position.

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*This lesson plan supersedes LP 38-520-0740, 104.

B. Objectives

1. Identify by name the position and anatomical structures demonstrated of the Settegast view of the knee.

2. State the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization, film identification and captioning necessary to demonstrate the position(s) of the Settegast view of the knee.

3. Given a request slip and a simulated patient in the X-ray laboratory select the proper technical factors, accessary equipment and the correct positioning data which would produce a technically acceptable radiograph(s) of the Settegast view of the knee.

C. Class Procedure and Lesson Tie-in

1. Students will gather around the x-ray table during the demonstration.

2. Students will demonstrate these positions in their laboratory practical exercise on crucial objectives.

II. DEMONSTRATION (40 min)

A. Anatomical Structures Demonstrated -- Knee

NOTE: Place radiographs on viewbox and point out the following anatomical structures:

1. Patella (axial view)

2. Femoral--patella interspace

B. Position

NOTE: Refer to Annex A and B for explanation of positions and have students fill in their GR's.

Settegast (Supine and Prone)

NOTE: Instructor emphasize the prone Settegast is the preferred position.

NOTE: Emphasize restricting conefield to 6 inches, using correct marker in conefield.

QUESTION: What is the angle and direction of the central ray?

ANSWER: 30 degrees cephalic off the long axis of the tibia.

QUESTION: What is the alignment for the prone position?

ANSWER: Epicondyles are parallel to the film and the thigh and leg forms 80 degrees.

C. Demonstrate positions using information in Annexes A and B.

NOTE: Positions will be demonstrated by the instructor using a student from the class as a patient and refer students to the order of procedure.

D. Questions From Students

NOTE: Make study assignment: After class study GR 38-520-027-1A and TM 8-280, pp 10-43.

III. SUMMARY (3 min)

A. Review of Main Points

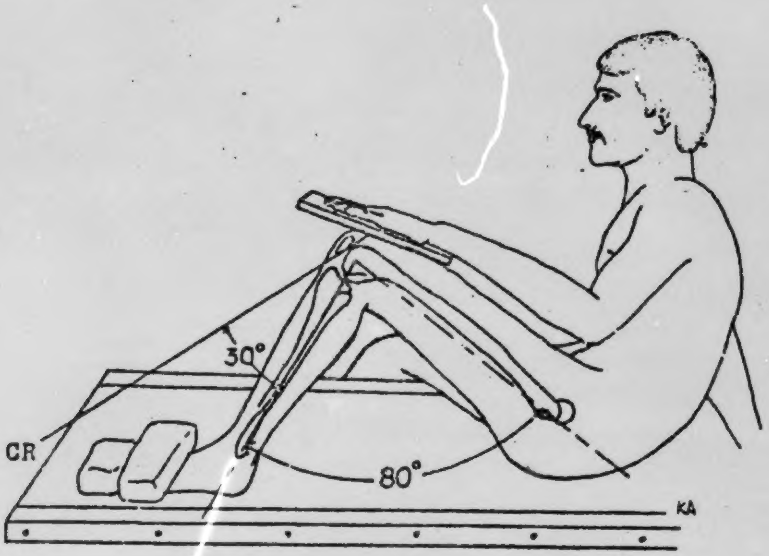
1. Anatomical Structures

2. Positions

3. Demonstration

B. Closing Statement: The student must keep in mind that while the views just discussed are nearly always considered special views, they will occasionally be called for in any large X-Ray Clinic, and there is the possibility that they could be done as a clinical routine in some clinics.

Patella, Axial Projection (Settegast, Supine Position)



Knee Position (Supine) Settegast

CRPR: Apex of patella projected to center of film holder

Film Rundown: 8 x 10, LW, NB CR: Cephalic to form 30° angle to tibia Cone: 6"

Alignment: Part centered, Epicondyles parallel to film. Femur and Tibia form an angle of 80°

Demonstrates: Axial view of patella and femoral patellor interspace

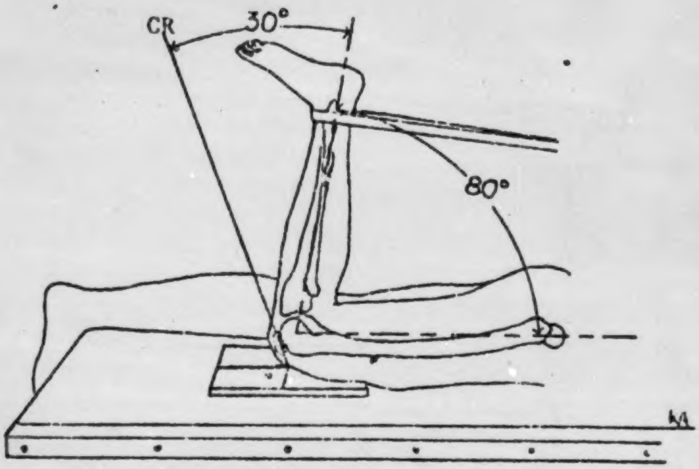
Notes: FFD: 40" ID: Either lateral border within the conefield

1. IMMOBILIZATION: Place sandbag over the foot of side under study.
2. Patient seated or supine holding film flat against anterior aspect of thigh.
3. Do supine position if patient cannot assume prone position.

TM 8-280 pp. 10-43 Figure 10-38

1002

Patella, Axial Projection (Settegast, Prone Position)



Knee Position (Prone) Settegast

CRPR: Apex of patella projected to center of film holder

Film Rundown: 8 x 10, LW, NB CR: Cephalic to form 30° angle to tibia Cone: 6"

Alignment: Part centered, Epicondyles parallel to film, Femur and Tibia form an angle of 80°.

Demonstrates: Axial view of Patella and Femoral Patellar Interspace

Notes: FFD: 40" ID: Either lateral border within the conefield

1. IMMOBILIZATION: Use belt-type traction around ankle.

2. Prone Settegast is the position of choice because of the limitations of equipment.

1004

TM 8-280 pp. 10-43 Figure 10-38

1003

SFC JIMMIE BINKLEY
*LP 38-520-044
076

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

Positioning of the Lower Extremity: Femur (1 hour)

COURSES PRESENTED TO: Radiographic Procedures (Basic), 313-91P20

PLACE: Classroom

REFERENCES:

TM 8-280, pp 477-481.
Merrill, Vinita. Atlas of Roentgenographic Positions. 3d ed., Vol. I. St. Louis, Missouri: The C·V. Mosby Company, 1967, pp 106-and 107.

STUDY ASSIGNMENT: After class study GR 38-520-027-1A and TM 8-280, pp 10-44 and 10-45.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 and GR 38-520-027-1A.

TOOLS, EQUIPMENT, AND MATERIALS: GR 38-520-027-1A issued at beginning of sixth week.

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Radiographs of the femur; pointer; radiographic illuminator· chalkboard, chalk, and eraser; PA system with lapel mike (see Annex A thru D)

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

I. INTRODUCTION (2 min)

A. Opening Statement: Picture yourself as an X-Ray Specialist working in a field hospital. A casualty has just been brought in from the combat zone with a severe injury to his thigh. Your quick and efficient action to provide suitable radiographs for the radiologist may save this man's leg; it may even save his life! I'm sure that each one of you can see the tremendous responsibility you will undertake as an X-Ray Specialist, and through a sound knowledge of radiographic procedures, you will be able to apply the necessary action to produce diagnostic radiographs.

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*This lesson plan supersedes LP 38-520-044, 074.

B. Objectives

1. Identify by name the position and anatomical structures demonstrated of the routine views of the distal and proximal femur.

2. State the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization, film identification and captioning necessary to demonstrate the positions of the routine views of the distal and proximal femur.

3. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiograph(s) of the routine distal and proximal femur.

C. Class Procedure and Lesson Tie-in

1. Students will gather around the x-ray table during the demonstration.

2. Students will demonstrate these positions in their laboratory practical exercise on crucial objectives.

II. DEMONSTRATION (40 min)

A. Anatomical Structures Demonstrated — Femur

NOTE: Place radiographs on the viewbox and point out the following anatomical structures:

1. Proximal tibia and fibula
2. Patella
3. Distal femur
    a. Medial epicondyles
    b. Lateral epicondyles
    c. Intercondyloid fossa
4. Shaft of femur
5. Proximal femur
    a. Greater trochanter
    b. Lesser trochanter
    c. Head and neck

6. Innominate Bone

   a. Acetabulum

   b. Ischium

   c. Pubis

   d. Symphysis pubis

NOTE: Hip joint is the head and neck of the femur and the acetabulum of the innominate bone.

QUESTION: If the site of injury is in the proximal third of the femur, what joint would be included in the routine femur?

ANSWER: The hip joint.

NOTE: Refer to Annexes A thru D for explanation of positions and have the students fill in their GR's.

B. Positions

   1. Distal (routine)

      a. AP

      b. Lateral

   2. Proximal (routine)

      a. AP

      b. Lateral

C. Demonstrate positions using the information in Annexes A thru D.

NOTE: Positions will be demonstrated by the instructor using a student from the class as a patient and refer students to the order of procedure.

NOTE: On lateral distal femur have the patient in the lateral position, draw unaffected extremity forward resting it on sandbags. Have patient grasp the side of the table with uppermost hand to aid in maintaining the position.

NOTE: Stress that the epicondyles are parallel to the film on the AP position and perpendicular on the lateral position.

1006

LP 38-520-044
076

NOTE: Stress that initially the patient is laterally recumbent for proximal lateral position with the affected side down, affected knee flexed 45 degrees, complete lower extremity, greater trochanter to midpoint of knee over center line of table; and that the patient is now rotated backward 45 degrees (keeping the affected femur in the same position) moving the unaffected extremity backward so as not to obscure the affected femur.

D. Questions From Students

NOTE: Make assignment: After study study TM 8-280, pp 10-44 and 10-45 and GR 38-520-027-1A.

III. SUMMARY (3 min)

A. Review of Main Points

1. Anatomical Structures

2. Positions

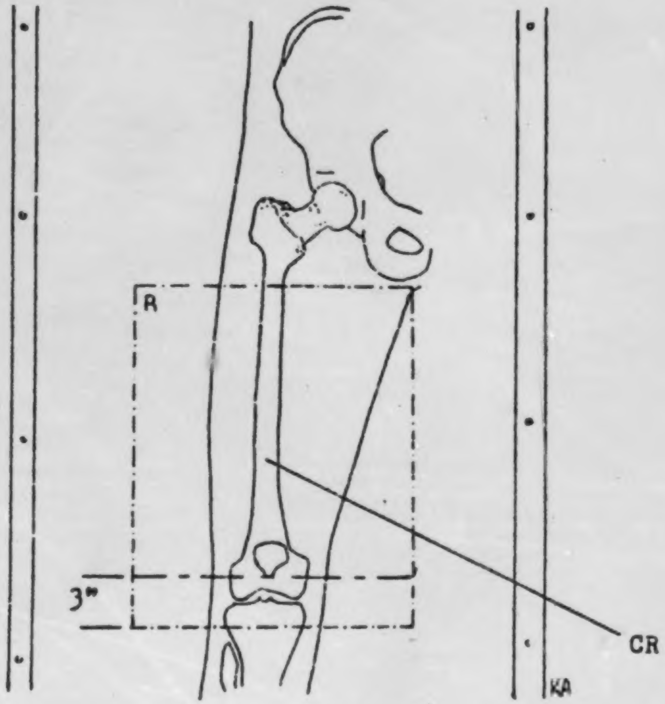
3. Demonstration

B. Closing Statement: Remember, you may be called upon to apply this knowledge in an emergency situation. A man's limbs and possibily his life may be placed in your hands.

ANNEX A
INSTRUCTIONAL AIDS

Femur

Routine: AP and Lateral (Proximal or Distal)



Femur Position AP Distal

PFR: Apex of Patella 3" above lower border of film holder

Film Rundown: 14 x 17, L W, B CR: VP Cone: FFC

Alignment Epicondyles parallel with table top and a plane thru the ASIS and mid-Epicondyles over the center line of table

Demonstrates: Knee joint and distal 2/3 of the Femur

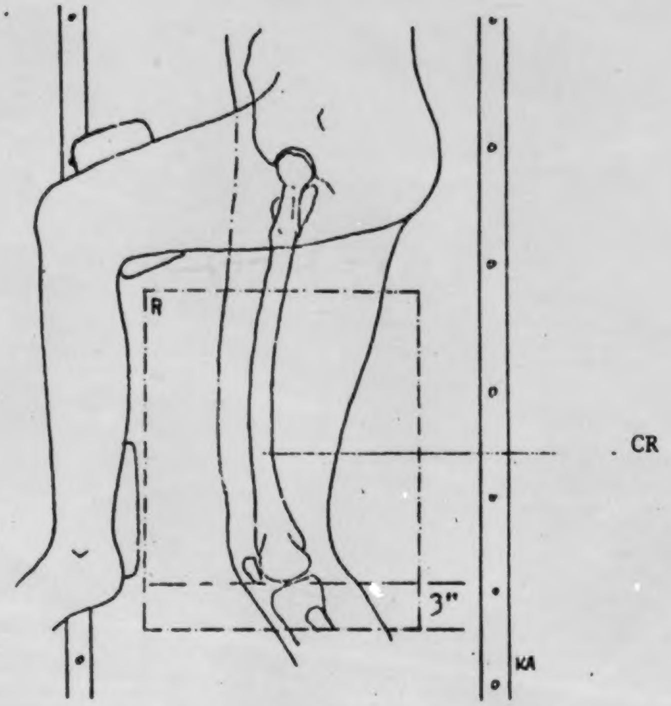
Notes: FFD: 40 " ID: Either lateral border

1. IMMOBILIZATION: Place sandbags against both sides of leg.
2. Cathode Reference: Cephalic
3. Patient Dress: Clothing from waist down removed and dressed in a gown.

TM 8-280 pp. 10-44 Figure 10-39

Femur

Routine: AP and Lateral (Proximal or Distal)



Femur Position Lateral Distal

PFR: Apex of Patella 3" above lower border of film holder

Film Rundown: 14 x 17, L W, B CR: VP Cone: FFC

Alignment: Epicondyles perpendicular, and a plane thru Greater Trochanter and midmedial surface of the knee over the center line of the table. Knee flexed approximately 45°

Demonstrates: Knee joint and distal 2/3 of Femur

Notes: FFD: 40 " ID: Either lateral border

IMMOBILIZATION: Place sandbag across leg of affected side and support unaffected extremity on sandbag.

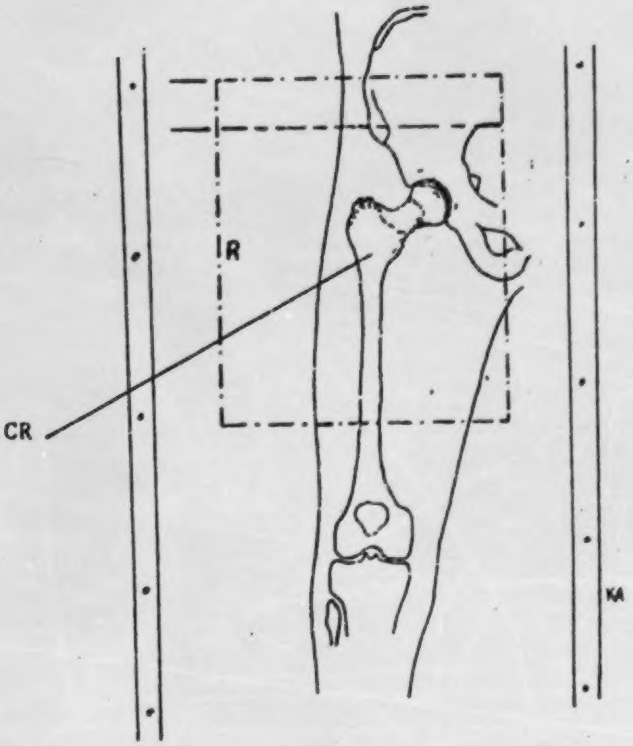
Patient Dress: Clothing from the waist down removed and dressed in a gown.

Draw unaffected leg forward, as shown in graph and rest on sandbags.

INSTRUCTIONAL AIDS

Femur

Routine: AP and Lateral (Distal or Proximal)



Femur Position AP Proximal

PFR: ASIS 3" below upper border of film holder

Film Rundown: 14 x 17, LW, B CR: VP Cone: FFC

Alignment: Epicondyles parallel with table top and a plane thru ASIS and mid-Epicondyles over center line of table

Demonstrates: Hip joint and proximal 2/3 of Femur

Notes: FFD: 40 " ID: Either lateral border

1. IMMOBILIZATION: Place sandbags against both side of the leg.
2. Cathode Reference: Cephalic
3. Patient Dress: Clothing from the waist down removed and dressed in gown

TM 8-280 pp. 10-44 Figure 10-39

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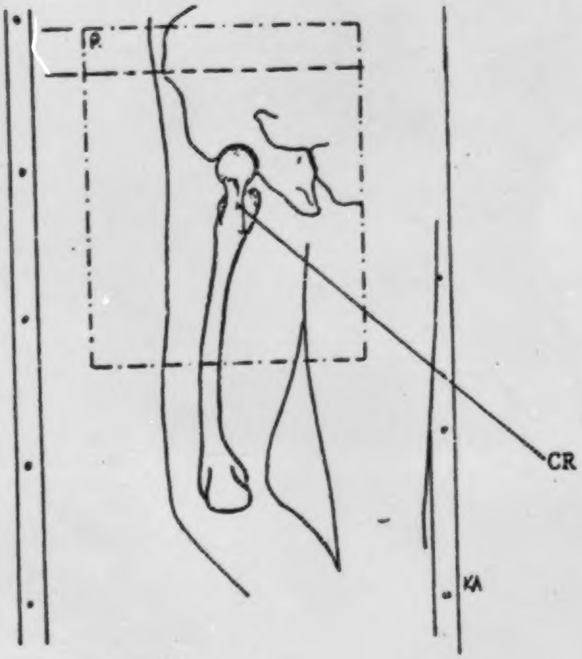
ANNEX D
INSTRUCTIONAL AIDS

Femur

Routine: AP and Lateral (Distal or Proximal)



Femur Position Lateral Proximal

PFR: ASIS 3" below upper border of film holder.

Film Rundown: 14x17, L W, B CR: VP Cone: FFC

Alignment: Epicondyles perpendicular and a plane thru the Greater Trochanter and the mid-medial surface of the knee over the center line of the table. Knee flexed approximately 45°

Demonstrates: Hip joint and proximal 2/3 of femur

Notes: FFD: 40 " ID: Either lateral border

1. IMMOBILIZATION: Place sandbag across leg of affected side.
2. Cathode Reference: Cephalic
3. Patient Dress: Remove clothing from waist down and dressed in a gown
4. With patient laterally recumbant, bring unaffected femur backwards to prevent super-imposition of femurs. Also patient can grasp side of table to aid in maintaining the position.

1012

TM 8-280 pp. 10-45 Figure 10-40

1011

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*LP 38-520-046
076

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE & SURGERY
X-RAY BRANCH

Positioning of the Lower Extremity: Pelvis (1 hour)

COURSES PRESENTED TO: Radiographic Procedures (Basic), 313-91P20

PLACE: Classroom

REFERENCES:

TM 8-280, pp 10-49 and 10-50
Merrill, Vinita. Atlas of Roentgenographic Positions. 3d ed, Vol I, St. Louis, Missouri: C. V. Mosby Company, 1967, pp 180-181, 182-185

STUDY ASSIGNMENT: After class study GR 38-520-027-1A and TM 8-280, pp 10-49 and 10-50.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 and GR 38-520-027-1A.

TOOLS, EQUIPMENT, AND MATERIALS: GR 38-520-027-1A issued at beginning of sixth week.

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Radiographs of the pelvis; pointer; radiographic illuminator; chalkboard, chalk, and eraser; PA system with lapel mike (see Annexes A and B)

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

I. INTRODUCTION (4 min)

A. Opening Statement: Unlike patients who come to your clinic for something as simple as a hand routine, those coming for pelvis radiographs may be completely immobilized by their injuries and in great pain

NOTE: Show radiograph. The pain associated with pelvic injuries, and the location of the reproductive organs are factors that must be considered when positioning the pelvis.

---

*This Lesson Plan supersedes LP 38-520-046, 064

1012

B. Objectives

1. Identify by name the position and anatomical structures demonstrated of the routine and additional views of the pelvis.

2. State the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization, film identification and captioning necessary to demonstrate the positions of the routine and additional views of the pelvis.

3. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiograph(s) of the routine and additional views of the pelvis.

C. Class procedure and lesson tie-in

1. Students will gather around the X-ray table during the demonstration.

2. Students will demonstrate these positions in their laboratory practical exercise on crucial objectives.

II. DEMONSTRATION (35 min)

A. Anatomical Structures Demonstrated - Pelvis

NOTE: Place radiographs on viewbox and point out the following anatomical structures:

1. Innominate

a. Illium

(1) Crest

(2) Anterior-superior iliac spine (ASIS)

(3) Acetabulum (2/5)

b. Ischium (posterior)

(1) Obturator foramen

(2) Ischial spine

(3) Ischial tuberosity

1014

17

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- (4) Ramus
- (5) Acetabulum (2/5)

- c. Pubis (anterior)
  - (1) Ramus
  - (2) Symphysis pubis
  - (3) Acetabulum (1/5)

2. Head and neck of femur
   - a. Greater trochanter
   - b. Lesser trochanter
3. Sacrum
   - a. Sacro-iliac joint
   - b. Sacrococcygeal joint
4. Coccyx
   - a. Apex
   - b. Base

NOTE: Instructor stress importance of protecting reproductive organs in pelvic region from radiation.

NOTE: Review rule for identifying radiographs of the trunk.

QUESTION: What palpation point is at the level of the symphysis pubis?

ANSWER: The greater trochanter.

QUESTION: Name the three parts of the innominate bone.

ANSWER: Ilium, ischium, and pubis.

B. Positions

NOTE: Refer to Annexes A and B for explanation of positions and have the students fill in their GR's.

1. AP pelvis (routine)

1014

2. Spread pelvis (additional)

C. Demonstrate positions using information in Annexes A and B.

NOTE: Position will be demonstrated by the instructor using a student from the class as a patient and refer students to the order of procedure.

QUESTION: What is the PFR for the AP pelvis?

ANSWER: Plane thru Superior Prominence of Iliac Crests 3" below upper border of the film holder.

NOTE: Stress that in the AP projection, the feet and legs are rotated medially 15° from the vertical to bring the head and neck of the femurs parallel to the film.

QUESTION: What is the PFR for the spread pelvis?

ANSWER: Plane thru Superior Prominence of Iliac Crests 3" below upper border of the film holder.

D. Questions from students.

NOTE: Make study assignment: After class study GR 38-520-027-1A and TM 8-280, pp 10-49 and 10-50.

III. SUMMARY (6 min)

A. Review of main points

1. Anatomical Structures

2. Positions

3. Demonstration

B. Closing statement: Patient care and handling, as well as radiation protection are of prime importance in positioning the pelvis. Good positioning techniques are necessary to produce satisfactory radiographs with a minimum of patient discomfort and radiation.

1016

ANNEX A
INSTRUCTIONAL AIDS

LP 38-520-046
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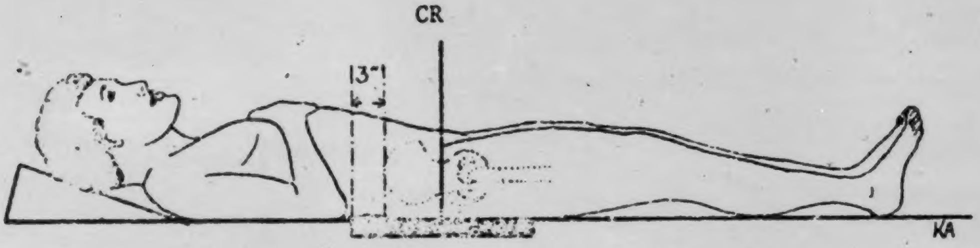
Pelvis

Routine: AP

Additional: Spread or Frog Position



Pelvis Position AP

PFR: Plane thru Superior Prominence of Iliac Crests 3" below upper border of the film holder.

Film Rundown: 14x17, CW, B

ID: Either lateral border

CR: VP

Cone: FFC

Alignment: Vertebral column over center line of table, lower extremities fully extended, with feet and legs rotated 15° medially

Breathing Technique: Suspended Respiration

FFD: 40"

Demonstrates: Bony structures of the pelvic girdle and both hip joints.

Notes: IMMOBILIZATION: Place sandbags against both feet.

2. To prevent foreshortening of the heads and necks of femurs, rotate feet and legs 15° medially

3. Patient Dress: Clothing from waist down removed and dressed in a gown.

4. Cathode Reference: Caudad

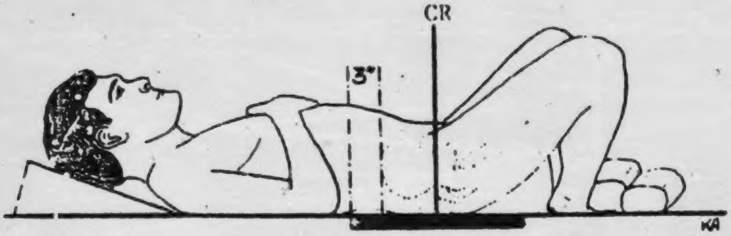
1017

ANNEX B
INSTRUCTIONAL AIDS

Pelvis

Routine: AP

Additional: Spread or Frog Position



Pelvis Position Spread

PFR: Plane thru Iliac Crests 3" below upper border of film holder

Film Rundown: 14x17, CW, B ID: Either lateral border

CR: VP Cone: FFC

Alignment: Vertebral column over center line of table. Soles of feet placed together and thighs are equally abducted as far as injury will permit. (Approx 80°)

Breathing Technique: Suspended respiration FFD: 40"

Demonstrates: Lateral projection of the head and neck of both femurs.

Notes: 1. IMMOBILIZATION: Place sandbags against both feet and supporting legs.

2. Patient dress: Same as AP

3. Cathode Reference: Caudad

4. TM 8-280 Spread pelvis is explained with 10° cephalic CR and PFR: Plane thru the Ilian Crests 4" below upper border of film holder. Both methods are acceptable.

TM 8-280 pp. 10-49 Figure 10-44

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*LP 38-520-047
076

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

Positioning of the Lower Extremity: Hip (2 hours)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES:

TM 8-280, pp 10-46 thru 10-47.
Merrill, Vinita. *Atlas of Roentgenographic Positions*. 3d ed., Vol. I. St Louis: C·V. Mosby Company, 1967, pp 189-191.

STUDY ASSIGNMENT: After class study GR 38-520-027-1A and TM 8-280, pp 10-46 thru 10-47.

TOOLS, EQUIPMENT, AND MATERIALS: GR 38-520-027-1A issued at the beginning of sixth week.

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Chalkboard, chalk, and eraser; Radiographs of the hip, pointer, and radiographic illuminator; PA system with lapel mike; Articulated skeleton (see Annexes A and B)

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

FIRST HOUR

I. INTRODUCTION (5 min)

A. Opening Statement: In the so-called "Horse and Buggy" days of medicine, a fracture of the hip usually meant months of convalescence or a permanent disability. Now, in an everexpanding world of modern medicine and surgical techniques, the patient may be on his feet in a matter of weeks. To be part of this rapid-moving medical team, the x-ray specialist must have a thorough knowledge of the positions and techniques for the routine hip and be able to work quickly and easily under pressure. This will make him an asset to the clinic as well as to the orthopedic surgeon.

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*This lesson plan supersedes LP 38-520-047, 054.

B. Objectives

1. Identify by name the position and anatomical structures demonstrated of the routine views of the hip.

2. State the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization, film identification and captioning necessary to demonstrate the position(s) of the routine views of the hip.

3. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which produce a technically acceptable radiograph(s) of the routine views of the hips.

C. Class Procedure and Lesson Tie-in

1. Students will gather around the x-ray table during the demonstration.

2. Students will demonstrate these positions in their laboratory practical exercise on crucial objectives.

II. DEMONSTRATION (80 min)

A. Anatomical Structures Demonstrated — Hip

1. Innominate bones

2. Acetabulum

3. Head

4. Neck

5. Shaft—angle formed by neck and shaft 125 degrees

NOTE: Instructor must emphasize the angle formed by the neck and the shaft.

6. Greater trochanter

7. Lesser trochanter

B. Positions

NOTE: Refer to Annexes A and B for explanation of positions and have the students fill in their GR's.

1. Routine

    a. AP pelvis

    b. AP hip

NOTE: Explain how to locate the intersection of the asis and greater trochanter.

    c. Lateral hip

NOTE: At this point, instructor must explain grid cassettes, stationary grids, and their location in the lab area for usage in Surgery Room.

NOTE: At this point, explain the use of extension cylinders and restricted cone fields.

QUESTION: Why is the AP pelvis included as part of the routine?

ANSWER: For comparison of affected side with unaffected side.

C. Demonstrate positions using information in Annex A and B.

NOTE: Positions will be demonstrated by the instructor using a student from the class as a patient and refer students to the order of procedure.

1. AP Hip

NOTE: Student break here.

NOTE: During break, set up the lateral hip position using a skeleton as the patient.

SECOND HOUR

2. Lateral hip (dry bone demonstration)

NOTE: With the students around the machine, point out the pertinent facts about the procedure.

3. Lateral hip

NOTE: Position will be demonstrated by the instructor using a student from the class as a patient.

QUESTION: At what angle is the film placed in relation to the edge of the table?

ANSWER: 55 degree angle.

QUESTION: What type of film holder are we using?

ANSWER: A grid cassette.

D. Questions From Students

NOTE: Make assignment: After class study GR 38-520-027-1A and TM 8-280, pp 10-46 thru 10-47.

III. SUMMARY (5 min)

A. Review of Main Points

1. Anatomical structures

2. Positions

3. Demonstration

B. Closing Statement: Now that you have seen the routine for the hip, you can realize the importance of producing diagnostic films consistently for the radiologist and the orthopedic surgeon. A patient's future can depend on the radiograph you are taking. So, retire the "Horse and Buggy" days and take your position as an x-ray specialist in this world of modern medicine.

LP 38-520-047
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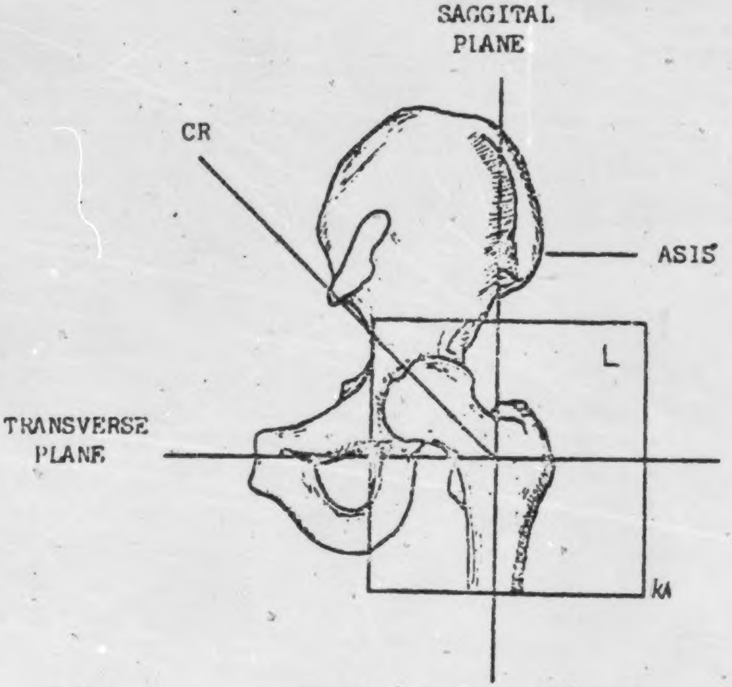
1021

ANNEX A
INSTRUCTIONAL AIDS

Hip

Routine: AP Pelvis, AP and Lateral Hip



Hip **Position** AP

PFR: Intersection of the Sagittal Plane (Paramedian) through the ASIS and the transverse plane thru the Greater Trochanter to center of film holder.

Film Rundown: 10 x 12, LW, B **ID:** Lateral to part within conefield

CR: VP **Cone:** 8"

Alignment: Part centered, with foot and leg rotated 15°

Breathing Technique: Suspended Respiration **FFD:** 40"

Demonstrates: AP head and neck of Femur and Acetabulum

Notes: 1. IMMOBILIZATION: Place sandbags against side of both feet.

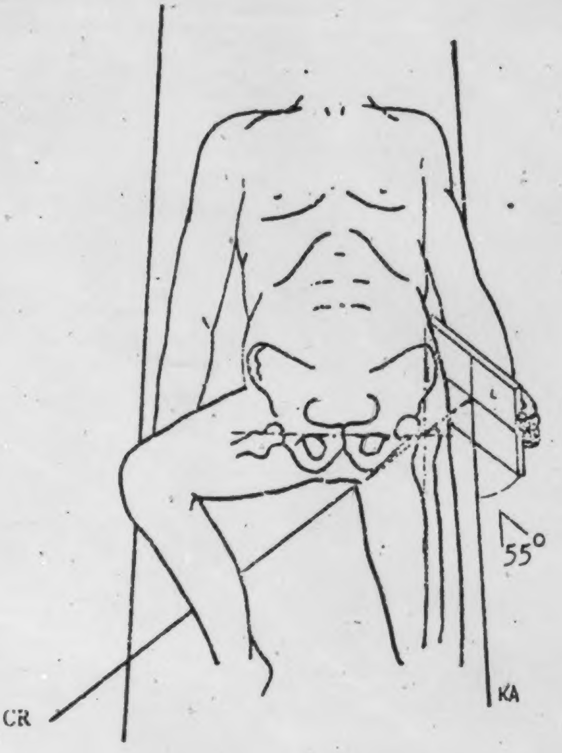
2. Patient Dress: Clothing from waist down removed and dressed in gown.

1022

ANNEX B
INSTRUCTIONAL AIDS

Hip

Routine: AP Pelvis, AP and Lateral Hip



PFR: Intersection of the Sagittal Plane (Paramedian) thru the ASIS and the transverse plane thru the Greater Trochanter to center of the film holder.

Film Rundown: 10x12, LW, Cassette ID: Above the part within the cone field.

CR: HP Cone: 8"

Alignment: Part centered, affected extremity fully extended, foot and leg rotated.

Breathing Technique: Suspended Respiration FFD: 40"

Demonstrates: Lateral view of head and neck of femur and acetabulum

Notes: 1. IMMOBILIZATION: Place sandbags against both sides of legs.

2. Patient is supine and moved to the outer edge of the table and the unaffected leg is drawn up and out of the way and placed on a support. (stool)

3. (INSTRUCTORS NOTE) Explain 55° as shown on the graph above.

1024

TM 8-280 pp. 10-47 Figure 10-42

1023

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076

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

Positioning of the Sacrum (1 hour)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES:

TM 8-280, pp 10-78 and 10-79.
Merrill, Vinita. Atlas of Roentgenographic Positions. Vol. I. 3d ed. St. Louis: C.V. Mosby Company, 1967, pp 216-217, 262-263.

STUDY ASSIGNMENT: After class study GR 38-520-027-1A and TM 8-280, pp 10-78 and 10-79.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 and GR 38-520-027-1A

TOOLS, EQUIPMENT, AND MATERIALS: GR 38-520-027-1A issued at beginning of sixth week.

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Chalk, chalkboard, and eraser; PA system with legal mike; Radiographs of the sacrum, pointer and x-ray illuminator (see Annexes A and B)

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

I. INTRODUCTION (5 min)

A. Opening Statement: It is common practice for young soldiers to lift and carry large heavy pieces of equipment improperly. Should the individual slip while carrying such an item, he may tear his muscles or ligaments incurring a subluxation of the sacrum. This will severely limit his ability to perform and will cause extreme pain. The medical officer may order radiographs of the sacrum. As X-Ray Specialists, a knowledge of these positions will be essential if you are to produce clinically acceptable radiographs.

---

* This lesson plan supersedes LP 38-520-0530, 044.

B. Objectives

1. Identify by name the position and anatomical structures demonstrated of the routine views of the sacrum.

2. State the correct routine. PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization, film identification and captioning necessary to demonstrate the position(s) of the routine views of the sacrum.

3. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessary equipment and the correct positioning data which would produce a technically acceptable radiograph(s) of the routine views of the sacrum.

C. Class Procedure and Lesson Tie-in

1. Students will gather around the x-ray table during the demonstration.

2. Students will demonstrate these positions in their laboratory practical exercise on crucial objectives.

II. DEMONSTRATION (35 min)

A. Anatomical Structures Demonstrated -- Sacrum

NOTE: Place radiographs on viewbox and point out the following anatomical structures.

1. Sacrum

a. Sacroiliac articulation

b. Ilium

c. Sacral promontory and body

d. Lumbosacral articulation

e. Base and apex

f. Sacral foramina

g. Auricular surfaces

B. Positions

NOTE: Refer to Annexes A and B for explanation of positions and have the students fill in their GR's.

1. Routine

a. AP

B. Lateral

NOTE: Median plane is placed over the centerline of the table for AP view; in the lateral view, coronal plane is perpendicular to the surface of the table. The anatomical structures utilized to position the coronal plane are: the acromion process and the superior prominence of the Iliac crest.

C. Demonstrate positions using information in Annexes A and B.

NOTE: Using student from the class as patient, demonstrate the positions, and emphasize the importance of patient being dressed in dressing gown for this procedure. Use information in Annexes A and B.

QUESTION: What is the angle and direction of the central ray for the AP sacrum?

ANSWER: Fifteen degrees cephalic.

QUESTION: What is the angle and direction of the central ray on lateral sacrum?

ANSWER: Vertical perpendicular.

QUESTION: Do we use a CRPR or a PFR when radiographing the lateral sacrum?

ANSWER: PFR.

D. Questions From Students

NOTE: Make study assignment: After class study GR 38-520-027-1A and TM 8-280, pp 10-78 and 10-79.

III. SUMMARY (5 min)

A. Review of Main Points

1. Anatomical structures

2. Positions

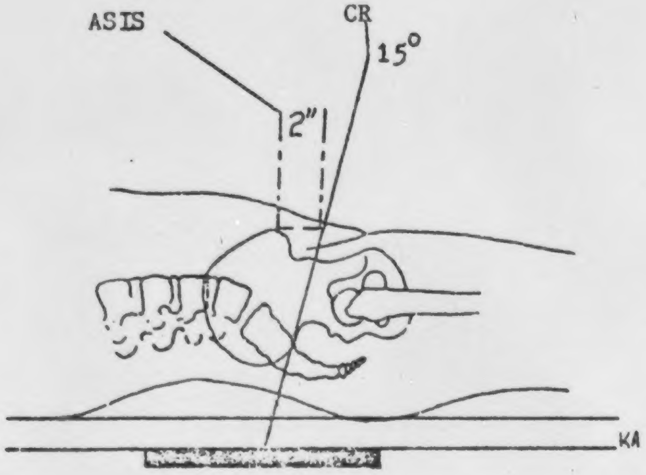
3. Demonstration

1026

B. Closing Statement: Picture yourself as the patient with trauma to this portion of anatomy; it hurts when you stand, when you sit, and even when you lie down. Would you like to climb up on the table, lie there for the examination, get down, and then have to do it all over again because the specialist made a mistake?

Sacrum

Routine: AP and Lateral



Sacrum Position AP

CRPR: A point 2" below mid-ASIS plane projected to center of film holder

Film Rundown: 10 x 12, LW, B ID: Either lateral border within conefield

CR: 15° Cephalic Cone: 8"

Alignment: Part centered, Median plane over centerline of table

Breathing Technique: Suspended Respiration FFD: 40"

Demonstrates: AP Sacrum

Notes: 1. Lower extremities fully extended

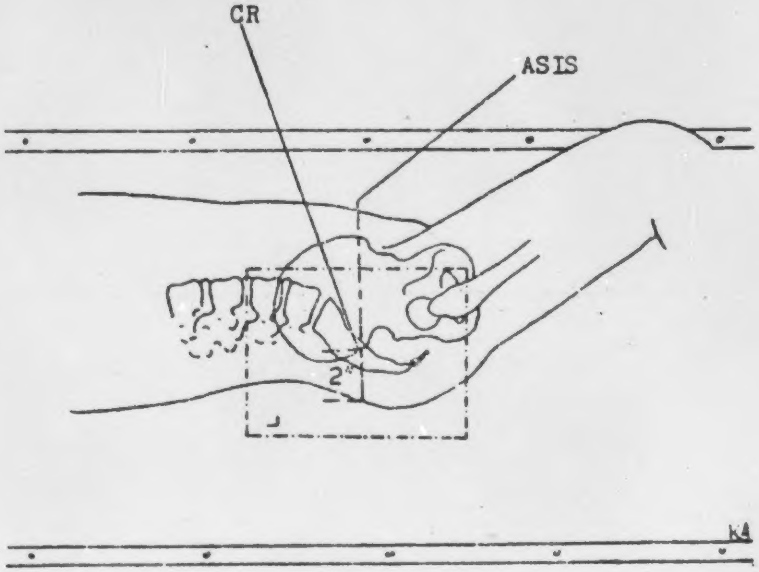
2. Patient Dress: Clothing from waist down removed and dressed in gown

3. Suspended respiration aids in immobilization.

ANNEX B
INSTRUCTIONAL AIDS

Sacrum

Routine: AP and Lateral



Sacrum Position Lateral

PFR: A point 2" anterior to the posterior skin surface at the level of the ASIS to center of film holder.

Film Rundown: 10 x 12, LW, B ID: Either lateral border within conefield

CR: VP Cone: 8 "

Alignment: Coronal plane perpendicular to table

Breathing Technique: Suspended Respiration FFD: 40 "

Demonstrates: Lateral Sacrum

Notes: 1. IMMOBILIZATION: Legs flexed forward for patient comfort and to aid in immobilization.

2. Patient Dress: Clothing from waist down removed and dressed in gown

3. Anatomical structures utilized to position the coronal plane are the acromion processes and the superior prominence of the iliac crest.

TM 8-280 pp. 10-79 Figure 10-73

1029

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076

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

Positioning of the Coccyx (1 hour)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES:

TM 8-280, pp 10-78 and 10-79.
Merrill, Vinita. Atlas of Roentgenographic Positions. 3d ed. Vol. I. St. Louis: C.V. Mosby Company, 1967, pp 216-217, 262-263.

STUDY ASSIGNMENT: After class study GR 38-520-027-1A and TM 8-280, pp 10-78 and 10-79.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280, and GR 38-520-027-1A.

TOOLS, EQUIPMENT, AND MATERIALS: GR 38-520-027-1A issued at beginning of sixth week.

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Chalk, chalkboard, and eraser; PA system with lapel mike; Radiographs of the coccyx, pointer and x-ray illuminator (see Annexes A and B)

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

I. INTRODUCTION (5 min)

A. Opening Statement: The coccyx, because of its position, poses a special problem to the X-Ray Specialist. To be properly demonstrated, it must be visualized through the pelvis with a minimum amount of distortation. During this period, you will see the application of positioning techniques necessary to meet these requirements.

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*This lesson plan supersedes LP 38-520-063, 044.

B. Objectives

1. Identify by name the position and anatomical structures demonstrated of the routine views of the coccyx.

2. State the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization, film identification and captioning necessary to demonstrate the position(s) of the routine views of the coccyx.

3. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessary equipment and the correct positioning data which would produce a technically acceptable radiograph(s) of the routine views of the coccyx.

C. Class Procedure and Lesson Tie-in

1. Students will gather around the x-ray table during the demonstration.

2. Students will demonstrate these positions in their laboratory practical exercise on crucial objectives.

II. DEMONSTRATION (35 min)

A. Anatomical Structures Demonstrated — Coccyx

NOTE: Place radiographs on viewbox and point out the following structures.

1. Coccyx

2. Sacrum

B. Positions

NOTE: Refer to Annexes A and B for explanation of positions and have the students fill in their GR's.

1. Routine

a. AP

b. Lateral

QUESTION: Which plane of the body should be over center line of table with patient in the supine position?

ANSWER: The median plane.

QUESTION: Which body plane must be perpendicular to the table with the patient in the lateral position?

ANSWER: The coronal plane.

NOTE: Patient lateral recumbent.

C. Demonstrate positions using information in Annexes A and B.

NOTE: Instructor will demonstrate the position using a student from class as patient and emphasize importance of patient being in dressing gown for this procedure.

D. Questions From Students

NOTE: Make study assignment: After class study GR 38-520-027-1A and TM 8-280, pp 10-78 and 10-79.

III. SUMMARY (5 min)

A. Review of Main Points

1. Anatomical Structures

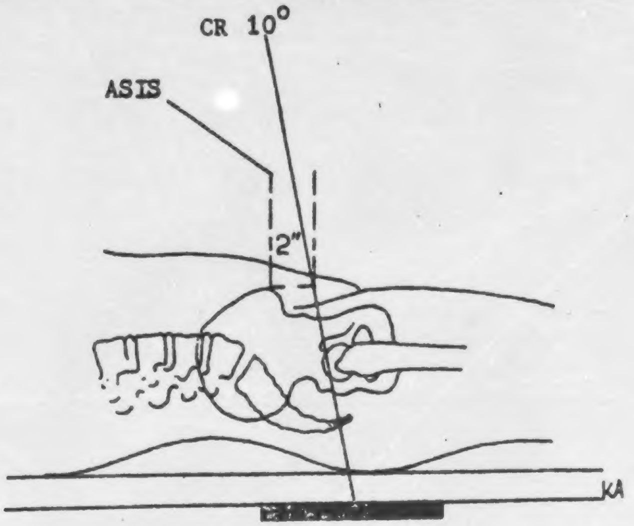
2. Positions

3. Demonstration

B. Closing Statement: The student technician must keep in mind that while the views just discussed are nearly always considered infrequent views, this does not warrant the attitude that the student will never have to take this routine. When you have to take this routine, to eliminate the possibility of excessive radiation to the patient, extra care must be taken in selecting the technical factors and facts about the position.

ANNEX A
INSTRUCTIONAL AIDS
Coccyx

Routine: AP and Lateral



Coccyx Position AP

CRPR A point 2" below mid-ASIS plane projected to center of film holder.

Film Rundown: 8 x 10, LW, B ID: Either lateral border within conefield

CR: 10° Caudad Cone: 6 "

Alignment: Part centered, Median plane over centerline of table

Breathing Technique: Suspended Respiration FFD: 40 "

Demonstrates: AP Coccyx

Notes: 1. Lower extremities fully extended

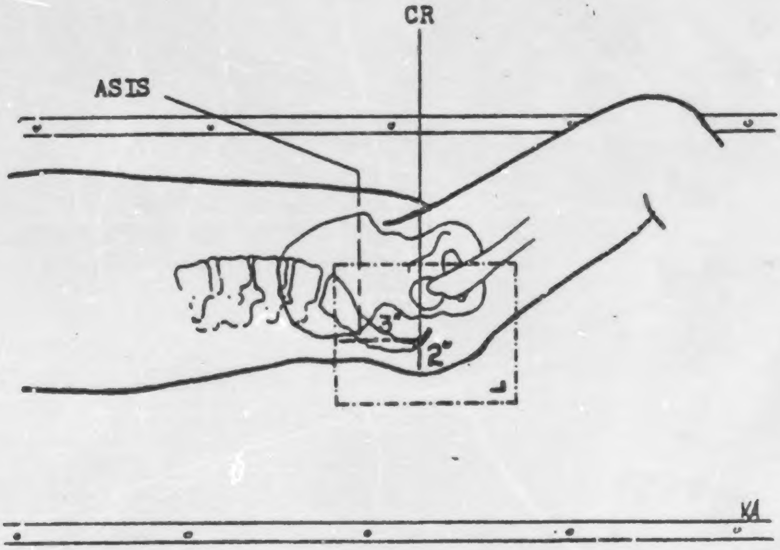
2. Patient Dress: Clothing from waist down removed and dressed in gown.

3. Suspended respiration to aid in immobilization.

TM 8-280 pp. 10-78 Figure 10-72

ANNEX B
INSTRUCTIONAL AIDS
Coccyx

Routine: AP and Lateral



Coccyx Position Lateral

PFR: A point 2" anterior to posterior skin surface, at a level 3" below the ASIS to center of the film holder.

Film rundown: 8 x 10, LW, B ID: Either lateral border within the conefield

CR: VP Cone: 6 "

Alignment: Coronal plane perpendicular to table

Breathing Technique: Suspended respiration FFD: 40 "

Demonstrates: Lateral Coccyx

Notes: 1. IMMOBILIZATION: Legs flexed forward for patient comfort and to aid in immobilization.

2. Patient Dress: Clothing from waist down removed and dressed in gown

TM 8-280 pp. 10-79 Figure 10-73

SFC JIMMIE BINKLEY
*LP 38-520-048
076

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

Film Discussion: Lower Extremity (2 hours)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES:

TM 8-230, pp 10-30 thru 10-51 and pp 10-78 and 10-79.
Merrill, Vinita. Atlas of Roentgenographic Positions. 3d ed. Vol. I. St. Louis, Missouri: C.V. Mosby Company, 1967, pp 60-106, 182-185, 189-191, 262-263.

STUDY ASSIGNMENT: After class study GR 38-520-027-1A and review sixth week film packet.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 and GR 38-520-027-1A.

TOOLS, EQUIPMENT, AND MATERIALS: None

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: PA system with lapel mike; Bank of viewboxes, pointer and radiographs of the lower extremity.

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

FIRST HOUR

I. INTRODUCTION (2 min)

A. Opening Statement: A part of your job as an X-Ray Specialist will be to examine the radiographs that you have taken and determine if they are acceptable by clinic standards. The fact that we do not take live exposures at the school makes it necessary that we conduct these film discussions periodically during the course. For the past several days, you have been positioning the lower extremity. During this block of instruction, you will see both acceptable routines and examples of some common errors found in positioning the lower extremity.

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*This Lesson Plan supersedes LP 38-520-048, 094.

1035

B. Objectives

1. List the routine and additional positions of the lower extremity and identify these on radiographs.

2. Given a radiograph of a lower extremity position:

   a. State the pertinent information necessary to produce that position.

   b. Identify and discuss any error(s) demonstrated on the radiograph.

   c. Identify anatomical structures demonstrated.

C. Class Procedure and Lesson Tie-in

1. This class was preceded by the following related blocks of instruction: Positioning of the Lower Extremity: Foot, Os Calcis, Ankle, Leg, Knee & Holmblad/Beclere Knee, Settegast Knee.

2. This class will be conducted by showing radiographs and discussing requirements for each position. Emphasis will be placed on areas as indicated by questions from the class.

II. EXPLANATION (38 min)

A. The Normal Radiograph

NOTE: Show one radiograph of each procedure progressing from foot through knee. Review each, requiring students to supply the following information.

1. Name of position

2. Part-to-film holder reference/central ray to part reference

3. Film rundown

4. Central ray/CRPR

5. Alignment

6. Anatomy demonstrated

7. Special considerations

1037

B. Common Errors

NOTE: Show one radiograph of each procedure progressing from foot through knee. Choose radiographs that demonstrate probable incorrect procedures for each position so that several factors will be discussed.

1. Film handling
2. Positioning
3. Central ray
4. Secondary factors of exposure

C. Questions From Students

III. SUMMARY (5 min)

A. Review of Main Points

1. The normal radiograph
2. Common errors

B. Closing Statement: During this hour, you have seen examples of both acceptable and unacceptable radiographs of the lower extremity, up to and including the knee. We will complete our film discussion on the lower extremity following your classes and practical exercises on the femur, pelvis, hip, sacrum and the coccyx.

SECOND HOUR

I. INTRODUCTION

A. Same as "FIRST HOUR"

B. Same as "FIRST HOUR"

C. Class Procedure and Lesson Tie-in

1. This class was preceded by the following related blocks of instruction: Positioning of the Lower Extremity: Femur, Pelvis, Hip, Sacrum and the Coccyx.
2. This class will be conducted by showing radiographs and discussing requirements for each position. Emphasis will be placed on areas as indicated by questions from the class.

II. EXPLANATION (40 min)

A. The Normal Radiograph

1037

NOTE: Show one radiograph of each procedure progressing from Femur through Coccyx. Review each, requiring students to supply the following information.

1. Name of position
2. Part-to-film holder reference/central ray to part reference
3. Film rundown
4. Central ray/CRPR
5. Alignments
6. Anatomy demonstrated
7. Special considerations

B. Common Errors

NOTE: Show one radiograph of each procedure progressing from Femur through Coccyx. Choose radiographs that demonstrate probable incorrect procedures for each position so that several factors will be discussed.

1. Film handling
2. Positioning
3. Central ray/CRPR
4. Secondary factors of exposure

C. Questions from Students

III. SUMMARY (5 Min)

A. Review of Main Points

1. The normal radiograph
2. Common errors

B. Closing Statement: When a repeat study is necessary, analyze the original radiograph and take the necessary measures to correct the errors.

1039

1038

SFC JIMMIE BINKLEY

ACADEMY OF HEALTH SCIENCES, US ARMY *LP 38-520-049
DIVISION OF MEDICINE AND SURGERY 076
X-RAY BRANCH

Positioning of the Trunk: Cervical Spine (2 hours)

COURSES PRESENTED TO: Radiographic Procedures (Basic), 313-91P20

PLACE: Classroom

REFERENCES:

TM 8-280, pp 10-67 through 10-69.
Merrill, Vinita. Atlas of Roentgenographic Positions, 3d ed, Vol I St. Louis: C. V. Mosby Company, 1967, pp 210-212, 220-230

STUDY ASSIGNMENT: After class study GR 38-520-027-1B and TM 8-280, pp 10-67 through 10-69

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 and GR 38-520-027-1B

TOOLS, EQUIPMENT, AND MATERIALS: GR 38-520-027-1B issued at beginning of seventh week.

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Radiographs of the cervical spine, pointer, and X-ray illuminator; chalkboard, chalk, and eraser, PA system with lapel mike. (see Annexes A through D)

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

I. INTRODUCTION (2 min)

A. Opening Statement: The cervical spine is one of the most dangerous examinations to the patient that an X-Ray Specialist will be required to perform. The most important thing to remember is that this patient must be handled with extreme care and should never be moved in cases of trauma without a medical officer present. The slightest mishandling could cause permanent damage or death to your patient.

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*This lesson plan supersedes LP 38-520-049, 064

1039

B. Objectives

1. Identify by name the positions and anatomical structures demonstrated of the routine and additional views of the cervical spine.

2. State the correct routine, PFR/CRPR, film rundown, cone-field, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization, film identification and captioning necessary to demonstrate the position(s) of the routine and additional view of the cervical spine.

3. Given a request slip and a simulated patient in the X-Ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiograph(s) of the routine and additional view of the cervical spine.

C. Class Procedure and Lesson Tie-in

1. Students will gather around the X-ray table during the demonstration.

2. Students will demonstrate these positions in their laboratory practical exercise on crucial objectives.

II. DEMONSTRATION (85 min)

A. Anatomical Structures Demonstrated - Cervical Spine

NOTE: Place radiograph on the viewbox and point out the following anatomical structures:

1. Cervical spine (7)
   a. Atlas (C-1)
   b. Axis (C-2)--odontoid process
   c. Spinous processes
2. Base of skull
3. Upper thoracic spine
4. Upper ribs
5. Clavicle (2)
6. Mandible

1041

a. Angles

b. Rami

c. Body

QUESTION: How do we count the cervical vertebrae in the AP projection?

ANSWER: Start at the 7th and count backwards.

B. Positions

NOTE: Refer to Annexes A through D for explanation of positions and have the students fill in their GR's.

NOTE: Write all terms in abbreviated form on the chalkboard.

1. AP (routine)

2. LAT (routine)

3. OM (routine)

4. Moving jaw (additional view)

5. Head alignments

NOTE: This is the first introduction to head alignments. Stress the purpose.

a. AP, open mouth, moving jaw--medial plane perpendicular, acanthio-meatal line perpendicular to film.

b. Lateral--median plane parallel, acanthio-meatal line parallel to floor

c. Demonstration of positions

C. Demonstrate positions using information in Annexes A through D.

NOTE: Positions will be demonstrated by the instructor using a student from the class as a patient and refer students to the order of procedure.

QUESTION: What is the CR-to-part reference for the AP position?

ANSWER: CR to midpoint of thyroid cartilage.

QUESTION: What are the two-way head alignments for AP, OM, and moving jaw?

ANSWER: Median plane and the acanthio-meatal line are perpendicular to the film.

QUESTION: What is the PFR for the LAT cervical position?

ANSWER: Midpoint of neck at the level of the thyroid cartilage to center of film.

NOTE: Stress that the AML is parallel to the floor on lateral view.

NOTE: Instructor emphasize that in cases of trauma a crosstable lateral may be requested prior to moving patient.

NOTE: Stress that the purpose for taking the open mouth is to visualize C-1 and C-2.

QUESTION: What is the purpose of the jaw moving during exposure?

ANSWER: To blur out the mandible so that entire cervical spine can be visualized on one AP view.

D. Questions from Students

NOTE: Make Study Assignments: After class study TM 8-280, pp 10-67 through 10-69 and GR 38-520-027-1B

III. SUMMARY (3 min)

A. Review of Main Points

1. Anatomical Structures

2. Positions

3. Demonstration

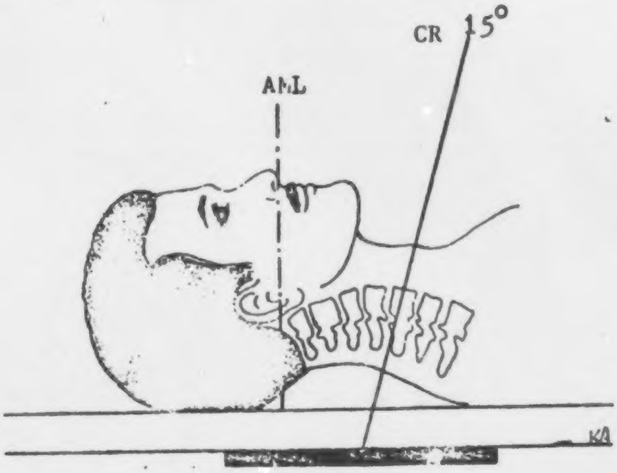
B. Closing Statement: Radiographic examinations of the cervical spine are extremely crucial. Your knowledge of proper patient handling and applications of the radiographic procedures discussed in this class may save the patient's life.

ANNEX A
INSTRUCTIONAL AIDS

Cervical Spine

Routine: AP, Open Mouth and Lateral

Additional: Moving Jaw



Cervical Spine Position AP

CRPR: Midpoint of thyroid cartilage projected to center of film holder

Film Rundown: 10 x 12, LW, B ID: Either lateral border

CR: 15° Cephalic Cone: FFC

Alignment: Median plane and Acanthiomeatal line perpendicular to film.

Breathing Technique: Suspended Respiration FFD: 40 "

Demonstrates: Lower 5 cervical vertebrae and soft tissue

Notes: 1. Median plane to center line of table.

2. * First two way head alignment

3. All artifacts removed (dentures, necklaces, eye glasses etc.) This applies to all views of the cervical spine

4. With all views of the spinal region, handle the patient with extreme care.

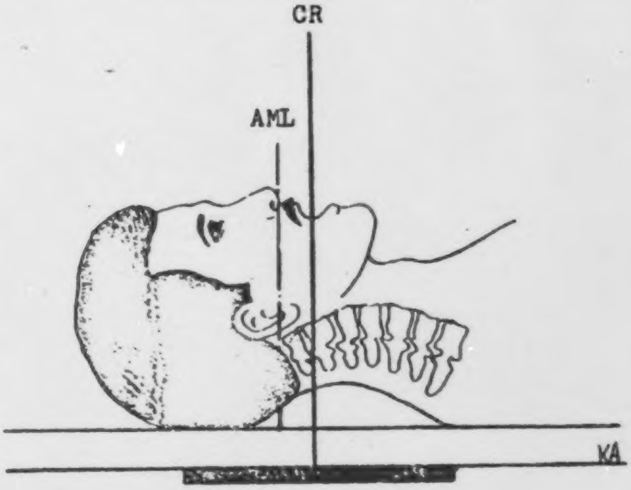
FM 8-230 pp. 10-67 Figure 10-61

1043

Cervical Spine

Routine: AP, Open Mouth and Lateral

Additional: Moving Jaw



Cervical Spine Position Open Mouth

PFR: Midpoint of open mouth to center of film holder

Film Rundown: 8 x 10, L W, B ID: Either lateral border withing conefield

CR: VP Cone: 6 "

Alignment: Median plane and Acanthio-meatal line perpendicular to film.

Breathing Technique: Suspended Respiration FFD: 40"

Demonstrates: C-1 and C-2 (Primarily for C-2 and the Odontoid Process)

Notes: 1. Median plane to center line of table

2. First two way head alignment

3. All artifacts removed (dentures, necklaces, eye glasses etc.) This applies to all views of the cervical spine.

4. With all views of the spinal region, handle the patient with extreme care

1045

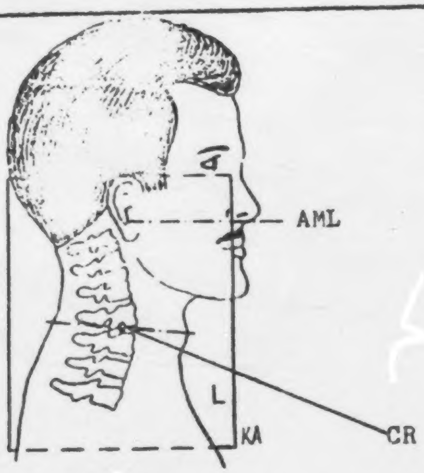
1044

LP 35-420-049
076

ANNEX C
INSTRUCTIONAL AIDS
Cervical Spine

Routine: AP, Open-Mouth, and Lateral

Additional: Moving Jaw



Cervical Spine Position Lateral

PFR: Mid-point of the neck at the level of the Thyroid Cartilage to center of film holder.

Film Rundown: 10 x 12, L W, NB ID: Either lateral border

CR: H P Cone: FFC

Aligment: Median plane parallel to film, Acanthio-meatal line parallel to floor

Breathing Technique: Suspended Respiration for immobilization FFD: 72 "

Demonstrates: All seven (7) cervical vertebrae

Notes: 1. Place sandbags of equal weight in hands to bring shoulders down to ensure visualization of C-7

2. 72 " FFD is used to minimize magnification because of large OFD.

3. Patient may be standing or seated erect

1046

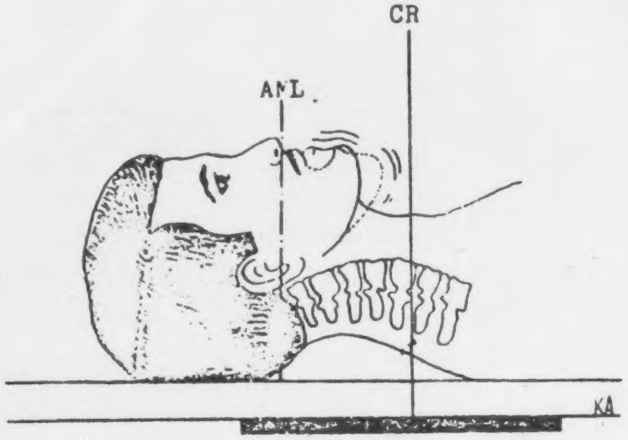
TM 8- 280 pp. 10-69 Figure 10-63

076 1045

INSTRUCTIONAL AIDS
Cervical Spine

Routine: AP, Open Mouth and Lateral

Additional: Moving Jaw



Cervical Spine Position Moving Jaw

PFR: Mid-point of the Thyroid Cartilage to the center of the film holder

Film Rundown: 10 x 12, L W, B ID: Either lateral border

CR: V P Cone: FFC

Alignment: Median plane and Acanthio-meatal line perpendicular to film.

Breathing Technique: Suspended Respiration for immobilization FFD: 40 "

Demonstrates: All seven (7)cervical vertebrae

Notes: 1. Median plane to center line of table

2. First two way head alignment

3. All artifacts removed (dentures, necklaces, eye glasses etc.) This applies to all views of the cervical spine.

4. With all views of the spinal region handle the patient with extreme care

5. Utilize a minimum exposure time of 3-5 seconds.

TM 8-280 pp. 10-67 Figure 10-61 (Variation)

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DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

LP 38-520-075
057

Errata Sheet No 2

Positioning: Additional Views Cervical Spine (1 hour)

LP 38-520-075, 126, is changed as follows:

1. Change LP No to read: 38-520-129, 057.
2. Change title to read: Positioning of the Oblique, Flexion and Extension Cervical Spine.

1047

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

LP 38-520-075
126

Errata Sheet No 1

Positioning: Additional Views

LP 38-520-075, 076, is changed as follows

A. Change Objectives to read:

1. Identify by name the position and anatomical structures demonstrated of the additional views of the cervical spine.

2. Determine the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization, film identification, and captioning necessary to demonstrate the position(s) of the additional views of the cervical spine.

3. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment, and the correct positioning data which would produce technically acceptable radiographic position(s) of the additional views of the cervical spine.

1048

SFC JIMMIE BINKLEY
*LP 38-520-075
076

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

Positioning: Additional Views

Cervical Spine (1 hour)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic) Course

PLACE: Classroom

REFERENCES:

TM 8-280, pp 10-69 and 10-70.
Merrill, Vinita. Atlas of Roentgenographic Positions. 3d ed., Vol. I. St. Louis, Missouri: C.V. Mosby Company, 1967, pp 210-212, 220-230.

STUDY ASSIGNMENT: After class study GR 38-520-027-1B and TM 8-280 pp 10-69 and 10-70.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 and GR 38-520-027-1B.

TOOLS, EQUIPMENT, AND MATERIALS: GR 38-520-027-1B issued at beginning of seventh week.

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Radiographs of the cervical spine, pointer, x-ray illuminators; chalkboard, chalk, and eraser; PA system with lapel mike (see Annexes A and B)

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

I. INTRODUCTION (2 min)

A. Opening Statement: Additional views of the cervical spine, the obliques and flexion-extension views, are taken to find the cause of pain not diagnosed on the routine series--whether the pain is the result of an injury or pathology.

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*This lesson plan supersedes LP 38-520-075, 094.

B. Objectives

1. Identify by name the position and structures demonstrated in the additional views of the cervical spine.

2. State the correct routine,PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization, film identification, and captioning necessary to demonstrate the position(s) of the additional views of the cervical spine.

3. Given a request slip and a simulated patient in the x-ray laboratory, select the proper technical factors, accessory equipment, and the correct positioning data which would produce technically acceptable radiograph(s) of the additional views of the cervical spine.

C. Class Procedure and Lesson Tie-in

1. Students will gather around the x-ray table during the demonstration.

2. Students will be demonstrating these positions in their laboratory practical exercise on crucial objectives.

II. DEMONSTRATION (40 min)

A. Anatomical Structures Demonstrated -- Cervical Spine

NOTE: Place radiograph on the viewbox and point out the following anatomical structures:

1. Cervical spine (seven)
    a. Atlas (C-1)
    b. Axis (C-2)--odontoid process
    c. Spinous processes
    d. Intervertebral foramina
2. Base of skull
3. Upper thoracic spine
4. Upper ribs
5. Clavicle (two)

6. Mandible
    a. Angles
    b. Rami
    c. Body

QUESTION: How do we count the cervical vertebrae in the AP projection?

ANSWER: Start at the seventh and count backwards.

B. Positions

NOTE: Refer to Annexes A and B for explanation of positions and have the students fill in their GR's.

1. Flexion/Extension (additional)
2. Oblique (additional)

NOTE: Patient erect or seated for all positions.

NOTE: Oblique views are made to check the intervetebral foramina for encroachment of calcium deposit.

C. Demonstrate positions using information in Annexes A and B.

NOTE: Positions will be demonstrated by the instructor using a student from the class as a patient and refer students to the order of procedure.

NOTE: LPO and RPO are taken with side up being demonstrated.

QUESTION: Why are oblique cervical spine views made?

ANSWER: To check intervertebral foramina for encroachment of calcium as in arthritis.

D. Questions From Students

NOTE: Made study assignment: After class study GR 38-520-027-1B and TM 8-280, pp 10-69 and 10-70.

III. SUMMARY (3 min)

A. Review of Main Points

1. Anatomical structures

1051

2. Positions

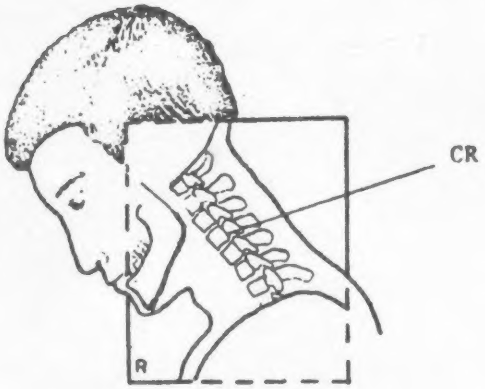
3. Demonstration

B. Closing Statement: Although the obliques and flexion-extension views of the cervical spine are not done routinely, patient handling is still critical. And remember that even though the patient's trouble may be the result of pathology and not an injury, the pain he experiences may be extreme. So if the patient cannot flex or extend his neck as far as you think he should--do not force him.

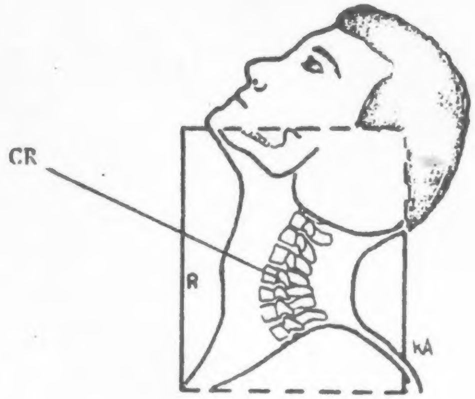
1053

ANNEX A
INSTRUCTIONAL AIDS

Flexion and Extension Cervical Spine Positions



Projection 1: Flexion



Projection 2: Extension

Additional Cervical Spine Positions: Flexion and Extension

PFR: Mid-point of neck at the level of Thyroid Cartilage to center of film holder

Film rundown: 10 x 12, L W, NB ID: Either lateral border

CR: H P Cone: FFC

Alignment: Median plane parallel to the film

Breathing Technique: Suspended Respiration for immobilization FFD: 72 "

Demonstratos: All seven (7) cervical vertebrae in extreme flexion and extension

Notes: 1. PFR is obtained with patient in normal lateral position

2. Sandbags of equal weight are placed in each hand to bring shoulders down

3. These two views are taken to determine the mobility of the cervical vertebrae

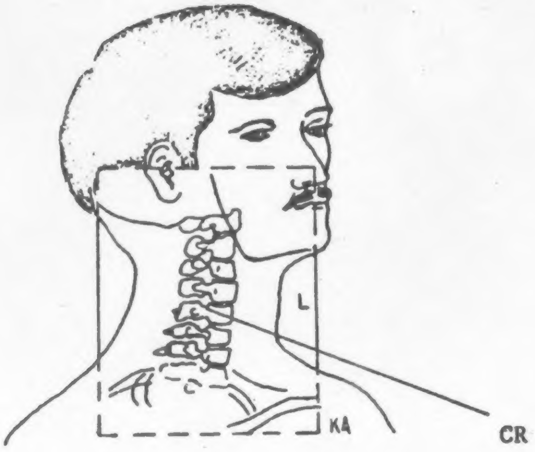
TM 8-280 pp. 10-69 Figure 10-63 (Variation)

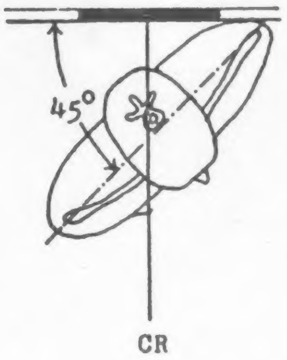
076 1053

INSTRUCTIONAL AIDS
Cervical Spine

Routine: AP, Open Mouth and Lateral

Additional: Oblique





Cervical Spine Position Oblique (LPO and RPO)

CRPR: Mid-point of the neck at the level of the Thyroid Cartilage to the center of the film holder

Film rundown: 10x12, L W, B ID: Either lateral border

CP: 15° Cephalic Cone: FFC

TWHA: Median Plane 45°, and Acanthio-meatal line perpendicular to film.

Breathing Technique: Suspended Respiration for immobilization FFD: 40 "

Demonstrates: Cervical vertebrae with emphasis on intervertebral foramina

Notes: 1. Both obliques are taken for comparison.

2. Demonstrates side away from the film, patient may be standing or seated erect.

Variations: 1. 72 " FFD, Non-bucky, CR, Horizontal Perpendicular (H P) all other information remains the same.

2. PA Obliques may be taken utilizing 40 " FFD, 15° Caudad CR, All other information remains the same 1055

TM 8-280 pp. 10-70 Figure 10-64

1054

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

LP 38-520-050
057

Errata Sheet No 2

Positioning of the Trunk: Dorsal Spine (1 Hour)

LP 38-520-050, 126, is changed as follows:

Change LP No to read: 38-520-130, 057.

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

LP 38-520-050
126

Errata Sheet No 1

Positioning of the Trunk: Dorsal Spine (1 hour)

LP 38-520-050, 076, is changed as follows:

A. Change Objectives to read:

1. Identify by name the positions and anatomical structures demonstrated of the routine views of the Dorsal spine.

2. Determine the correct routine, PFR/CRPR, film rundown, conefield angle and direction of the CR, FFD, alignment, breathing technique, immobilization, film identification and captioning necessary to demonstrate the position(s) of the routine views of the dorsal spine.

3. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiographic position(s) of the routine views of the dorsal spine.

1056

SFC JIMMIE BINKLEY

ACADEMY OF HEALTH SCIENCES, US ARMY *LP 38-520-050
DIVISION OF MEDICINE AND SURGERY 076
X-RAY BRANCH

Positioning of the Trunk: Dorsal Spine (1 hour)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES:

TM 8-280, pp 10-72 and 10-73
Merrill, Vinita. Atlas of Roentgenographic Positions. 3d ed, Vol I, St Louis: C. V. Mosby Company, 1967, pp 212-213, 240-245.

STUDY ASSIGNMENT: After class study TM 8-280, pp 10-72 and 10-73, and GR 38-520-027-1B

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 and GR 38-520-027-1B

TOOLS, EQUIPMENT, AND MATERIALS: GR 38-520-027-1B issued at beginning of seventh week.

PERSONNEL: One instructor (91P2H or 91P4H)

INSTRUCTIONAL AIDS: Radiographs of the dorsal spine; pointer and X-ray illuminator; chalkboard, chalk, and eraser; PA system with lapel mike (see Annexes A and B).

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

I. INTRODUCTION (2 min)

A. Opening Statement: What is the function of the dorsal spine? Most of you will probably think of it only as a support for the upper part of the body, but it does much more. It houses and protects the delicate spinal cord, it serves as a place for attachment for ribs and muscles, and it provides for mobility and flexibility of the upper part of the body. As X-ray Specialists, you are going to be responsible for positioning patients for the dorsal spine routine. It will be your responsibility to produce diagnostic radiographs of this part without causing further injury to the patient.

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*This lesson plan supersedes LP 38-520-050, 094

B. Objectives

1. Identify by name the positions and anatomical structures demonstrated of the routine views of the Dorsal spine.

2. State the correct routine, PFR/CRPR, film rundown, conefield angle and direction of the CR, FFD, alignment, breathing technique, immobilization, film identification and captioning necessary to demonstrate the position(s) of the routine views of the dorsal spine.

3. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiograph(s) of the routine views of the dorsal spine.

C. Class Procedure and Lesson Tie-in

1. Students will gather around the X-ray table during the demonstration.

2. Students will be demonstrating these positions in their laboratory practical exercise on crucial objectives.

II. DEMONSTRATION (40 min)

A. Anatomical Structures Demonstrated - Dorsal Spine

NOTE: Place radiographs on viewbox and point out the following anatomical structures.

1. Thoracic vertebra (12) concave anteriorly

2. Ribs (12PR)

3. Clavicles (2)

4. Lower cervical

5. Upper lumbar

B. Positions

NOTE: Refer to Annexes A and B for explanation of positions and have the students fill in their GR's.

1. AP (routine)

2. Lateral (routine)

NOTE: Emphasize that on lateral dorsal spine D-1 through D-3 are normally obscured because of shoulder superimposition.

NOTE: Cathode reference (anode heel effect) caudad to afford a more uniform density, due to body thickness in lower dorsal region.

C. Demonstrate positions using information in Annexes A and B.

NOTE: Positions will be demonstrated by the instructor using a student from the class as a patient and refer students to the order of procedure.

NOTE: Patient dress, remove all undergarments from shoulder to waist and have patient wear dressing gown.

QUESTION: What is aligned over the center line of the table for the AP position?

ANSWER: The median plane of the body.

QUESTION: What is aligned over the center line of the table for the lateral position?

ANSWER: Coronal plane of the body from the acromion process to the superior prominence of the iliac crest.

NOTE: When demonstrating the lateral, stress the importance and convenience to the Specialist when the patient lies with his back facing the working side of the table.

NOTE: When demonstrating the lateral, emphasize buttressing.

QUESTION: Why is buttressing important?

ANSWER: It makes the spine parallel to the table and therefore opens the intervertebral spaces.

D. Questions from Students

NOTE: Make Study Assignment: After class study TM 8-280, pp 10-72 and 10-73, and GR 38-520-027-1B.

III. SUMMARY (3 min)

A. Review of Main Points

1. Anatomical Structures

2. Positions

3, Demonstration

1059

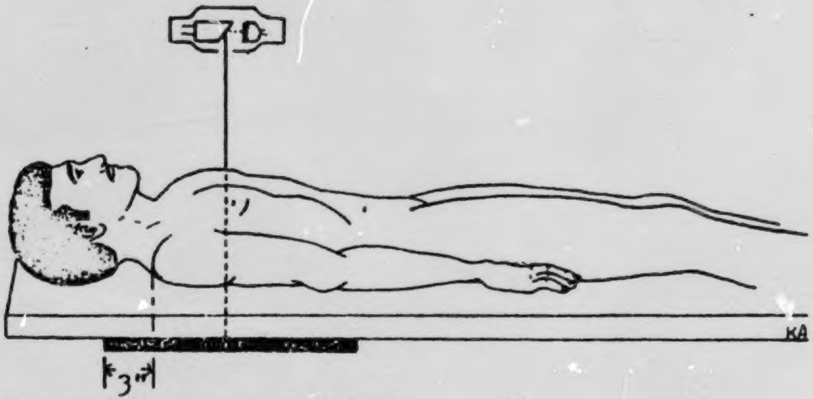
LP 38-520-050
076

B. Closing Statement: While serving as an Army X-ray Specialist, you will be called upon many times to perform examinations of the dorsal spine. Proper application of the knowledge you have gained today will enable you to produce diagnostic radiographs of this area.

1061

Dorsal Spine

Routine: AP and Lateral



Dorsal Spine Position A P

PFP: Plane thru Acromion Process 3" below upper border of film holder

Film Rundown: 14 x 17, L W, B ID: Either lateral border

CR: V P Cone: FFC

Alignment: Median plane perpendicular and over center line of table.

Breathing Technique: Suspended Expiration for uniform density FFD: 40 "

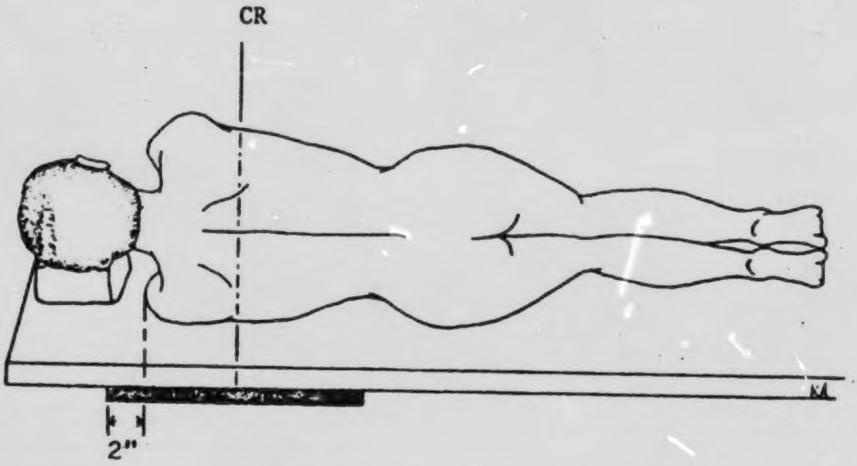
Demonstrates: All twelve (12) dorsal vertebrae and paraspinal soft tissue

Notes: 1. Cathode Reference: Caudad, for uniform density

2. Patient Dress: Clothing from waist up removed and patient dressed in gown.

Dorsal Spine

Routine: AP and Lateral



Dorsal Spine Position Lateral

PFR: Plane thru Acromion Process 2" below upper border of film holder

Film Rundown: 14 x 17, L W, B ID: Lateral border posterior to part

CR: V P Cone: FFC

Alignment: Coronal perpendicular to table and over center line of table.

Breathing Technique: Suspended Expiration for uniform density FFD: 40 "

Alternate Breathing Technique: Normal Breathing with long exposure time (3-5 second to blur out vascular markings.

Demonstrates: 4 thru 12 dorsal vertebrae and interspaces

Notes: 1. Coronal Plane (Acromion Process to Superior Prominence of Iliac Crest)

2. Buttress if necessary to bring the spine parallel to film, using radiolucent material in the area of the waist.

3. Patient Dress: Clothing from waist up removed and patient dressed in gown.

4. Knees flexed and arms at 90° to body to aid in immobilization.

TM 8-280 pp. 10-72 Figure 10-66

1062

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076

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

Positioning of the Trunk: Lumbar Spine (1 hour)

COURSES PRESENTED TO: Radiographic Procedures (Basic), 313-91P20

PLACE: Classroom

REFERENCES:

TM 8-280, pp 10-75 and 10-76
Merrill, Vinita. Atlas of Roentgenographic Positions. 3d ed, Vol I, St. Louis, MO: C. V. Mosby Company, 1967, pp 214-215; 246-251

STUDY ASSIGNMENT: After class, study GR 38-520-027-1B and TM 8-280, pp 10-75 and 10-76

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 and GR 38-520-027-1B

TOOLS, EQUIPMENT AND MATERIALS: GR 38-520-027-1B, issued at beginning of seventh week.

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Radiographs of the lumbar spine, pointer, and X-ray illuminator; chalkboard, chalk, and eraser; PA system with lapel mike (see Annexes A and B).

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

I. INTRODUCTION (2 min)

A. Opening Statement: Imagine being confined for the rest of your life to a wheel chair. I am sure that all of us have seen people in this situation. The first question which might come to mind is: "What caused this patient to be confined to a wheel chair?" One answer could be that he is paralyzed from a spinal injury. It is possible that mishandling of the patient could have caused this paralysis. As future X-ray specialists, we must caution you to be extremely careful in positioning patients with spinal injuries.

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*This lesson plan supersedes LP 38-520-053, 094

1063

B. Objectives

1. Identify by name the position and anatomical structures demonstrated of the routine lumbar spine.

2. State the correct routine, PFR/CRPR, film rundown, conefield, angle, and direction of the central ray, FFD, alignment, breathing technique, immobilization, film identification, and captioning necessary to demonstrate the position(s) of the lumbar spine.

3. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiograph(s) of the lumbar spine.

C. Class Procedure and Lesson Tie-in

1. Students will gather around the X-ray table during the demonstration.

2. Students will be demonstrating these positions in their laboratory practical exercise on crucial objectives.

II. DEMONSTRATION (40 min)

A. Anatomical Structures Demonstrated - Lumbar Spine

NOTE: Place radiographs on viewbox and point out the following anatomical structures.

1. Dorsal vertebrae

2. Lumbar vertebrae

    a. L-1

    b. L-2

    c. L-3

    d. L-4

    e. L-5

3. Sacrum

4. Ilium

QUESTION: Which lumbar vertebra is at the level of the iliac crest?

ANSWER: L-4.

5. Articulations
    a. Lumbosacral
    b. Sacro-iliac

B. Positions

NOTE: Refer to Annexes A and B for explanation of positions and have the students fill in their GR's.

1. AP (routine)
2. Lateral (routine)

NOTE: Emphasize the use of radiolucent buttressing material situated at waist level to place the spine parallel to the table.

C. Demonstrate Positions Using Information in Annexes A and B.

NOTE: Positions will be demonstrated by the instructor, using a student from the class as a patient and refer students to the order of procedure.

QUESTION: Why do we flex the legs in the AP view?

ANSWER: To lessen the lordotic curvature, bringing the spine closer and parallel to the table, therefore, opening up the joint spaces.

QUESTION: What is the part-to-film reference for both views?

ANSWER: Superior prominence of iliac crest 1 inch below the center of the film.

D. Questions from Students

NOTE: Make study assignment: After class study TM 8-280, pp 10-75 and 10-76 and GR 38-520-027-1B.

III. SUMMARY (3 min)

A. Review of Main Points
1. Anatomical Structures
2. Positions
3. Demonstration

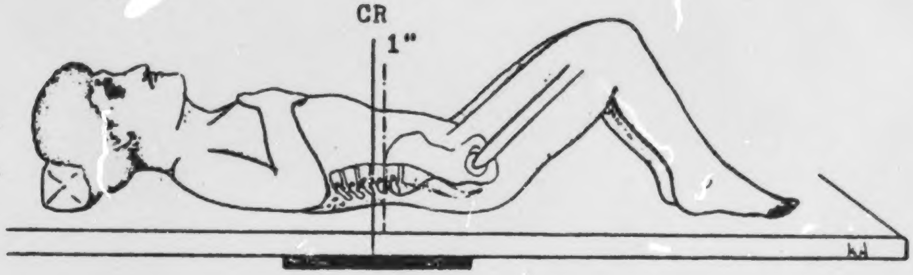
1065

B. Closing Statement: The lumbar spine routine is a frequently requested examination. Many times your patient may be seriously injured. As X-ray specialists, it is your responsibility to produce diagnostic radiographs of the lumbar spine and at the same time practice good patient handling to avoid the possibility of further injury to your patient.

1067

ANNEX A
INSTRUCTIONAL AIDS
Lumbar Spine

Routine: AP and Lateral



Lumbar Spine Position A P
Plane thru Superior Prominence of Iliac Crest

PFR: 1 " below center of film holder

Film Rundown: 14 x 17, L W, B ID: Either lateral border

CR: V P Cone: FFC

Alignment: Median plane perpendicular and over center line of table.

Breathing Technique: Suspended Respiration for immobilization FFD: 40 "

Demonstrates: Lumbar vertebrae and interspaces, soft tissues

Notes: 1. Cathode Reference: Caudad

2. Knees flexed with soles feet flat on table to lessen the lordotic curvature.

3. Patient Dress: Clothing from waist down removed and dressed in gown

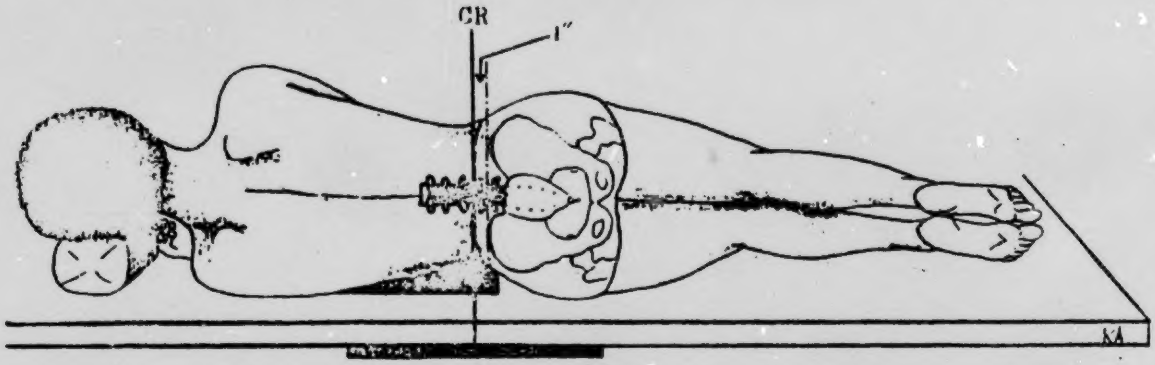
TM 8-280 pp. 10-75 Figure 10-69

LP 38-520-052
076

ANNEX B
INSTRUCTIONAL AIDS

Lumbar Spine

Routine: AP and Lateral



Lumbar Spine Position Lateral

PFR: Plane thru Superior Prominence of the Iliac Crest 1" below center of film holder

Film Rundown: 14 x 17, L W, B ID: Either lateral border

CR: V P Cone: FFC

Alignment: Coronal Plane perpendicular and over center line of table

Breathing Technique: Suspended Respiration for immobilization FFD: 40 "

Demonstrates: Lumbar Vertebrae and interspaces, soft tissues

Notes: 1. Cathode Reference: Caudad

2. Use radiolucent buttressing material under waist to place the spine parallel to the table.

3. Coronal Plane Reference: From the Acromion Process to the Superior Prominence of the Iliac Crest.

4. Knees flexed, and arms at 90° to body to aid in stability

5. Patient Dress: Clothing from waist down removed and dressed in gown.

TM 8-280 pp. 10-76 Figure 10-70

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*LP 38-520-051
076

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

Positioning of the Trunk: Lumbosacral Articulation (1 hour)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Trunk)

PLACE: Classroom

REFERENCES:

TM 8-280, pp 10-78 and 10-79.
Merrill, Vinita. Atlas of Roentgenographic Positions. 3d ed., Vol. I., St Louis: C.V. Mosby Company, 1967, pp 246-252.

STUDY ASSIGNMENT: After class study TM 8-280, pp 10-78 and 10-79 and GR 38-520-027-1B.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 and GR 38-520-027-1B.

TOOLS, EQUIPMENT, AND MATERIALS: GR 38-520-027-1B issued at beginning of seventh week.

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Radiographs of the lumbosacral articulation, x-ray illuminators, pointer; chalkboard, chalk, and eraser; PA system with lapel mike (see Annexes A and B)

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

I. INTRODUCTION (2 min)

A. Opening Statement: Complaint of low back pain is a common ailment in the military. The result of this complaint will call for an examination of the lumbosacral region. As future X-Ray Specialists, you will be required to properly position the routine lumbosacral articulation. This procedure necessitates precise positioning, an angled central ray, and a small cone-field.

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*This lesson plan supersedes LP 38-520-051, 044.

B. Objectives

1. Identify by name the position and anatomical structures demonstrated of the routine lumbosacral articulation.

2. State the correct routine, PFR/CRPR, film rundown, conefield angle and direction of the central ray, FFD, alignment, breathing technique, immobilization, film identification and captioning necessary to demonstrate the position(s) of the routine lumbosacral articulation.

3. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiograph(s) of the routine lumbosacral articulation.

C. Class Procedure and Lesson Tie-in

1. Students will gather around the x-ray table during the demonstration.

2. Students will be demonstrating these positions in their laboratory practical exercise on crucial objectives.

II. DEMONSTRATION (40 min)

A. Anatomical Structures Demonstrated -- Lumbosacral Articulation

NOTE: Place radiographs on illuminators and point out the following anatomical structures.

1. Fourth and fifth lumbar vertebrae

2. Sacrum

3. Sacro-iliac joints

B. Positions

NOTE: Refer to Annexes A and B for explanation of positions and have the students fill in their GR's.

1. AP (routine)

NOTE: Midsagittal plane is placed over the center of the table.

2. Lateral (routine)

1070

NOTE: Coronal plane perpendicular to table and over center line, knees forming 45 degree angle with body.

C. Demonstrate Positions Using Information in Annexes A and B

NOTE: Positions will be demonstrated by the instructor using a student from the class as patient and refer students to the order of procedure.

QUESTION: What is aligned over the center line of the table for the AP view?

ANSWER: The median plane of the body.

QUESTION: What is the PFR for the lateral view?

ANSWER: A point on the coronal plane midway between the superior prominence of the iliac crest and ASIS plane to the center of the film.

NOTE: Again stress, as in other recumbent spine positions, that the patient lies on his side with his back towards the working side of the table.

NOTE: Buttressing is essential in positioning the lateral lumbosacral spine.

D. Questions From Students

NOTE: Make study assignment: After class study TM 8-280, pp 10-78 and 10-79 and GR 38-520-027-1B.

III. SUMMARY (3 min)

A. Review of Main Points

1. Anatomical Structures

2. Positions

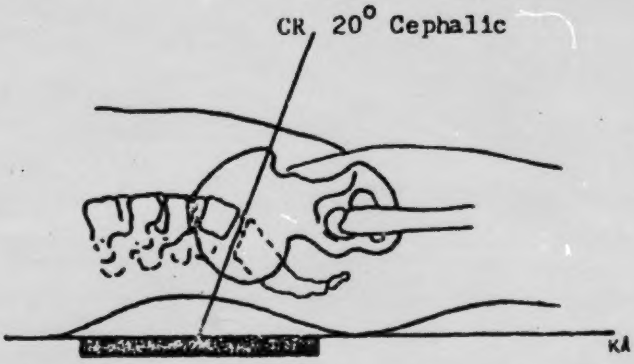
3. Demonstration

B. Closing Statement: Unless the proper central-ray-to-part and part-to-film references and patient alignments are used, you will be unable to produce diagnostic radiographs of the lumbosacral articulation. A conefield enables the technician to cut down on secondary radiation, but it also requires one to be more precise in positioning.

ANNEX A
INSTRUCTIONAL AIDS

Lumbosacral Articulation

Routine: AP and Lateral



Lumbosacral Articulation Position A P

CRPR: Midpoint between the ASIS projected to center of film holder

Film Rundown: 10 x 12, L W, B ID: Either lateral border within cone field

CR: 20° Cephalic Cone: 8 "

Alignment: Median Plane over center line of table

Breathing Technique: Suspended Respiration for immobiliz FFD: 40 "

Demonstrates: Lumbosacral and Sacroiliac Articulation

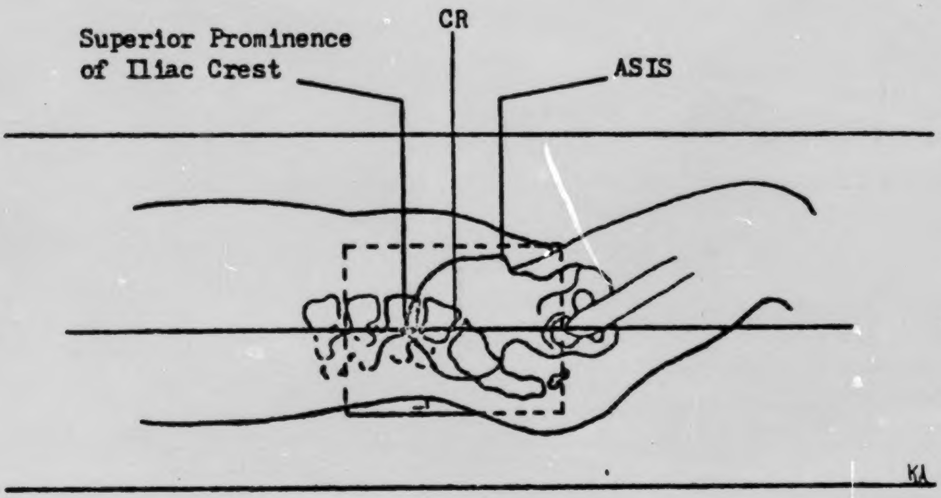
Notes: 1. Legs are not flexed

2. Patient Dress: Clothing from waist down removed and dressed in gown.

TM 8-280 pp. 10-78 Figure 10-72

Lumbosacral Articulation

Routine: AP and Lateral



Lumbosacral Articulation Position Lateral

PFR: Point on the Coronal Plane, midway between the ASIS and the Superior Prominence of the Iliac Crest to center of film holder.

Film Rundown: 10 x 12, L W, B ID: Either lateral border within cone field

CR: V P Cone: 8 "

Alignment: Coronal Plane perpendicular and over center line of table

Breathing Technique: Suspended Respiration FFD: 40 "

Demonstrates: Lumbosacral Articulation

Notes: 1. Coronal Plane Reference: From the Acromion Process to the Superior Prominence of the Iliac Crest.

2. Use buttressing to bring spine parallel to table

3. Patient Dress: Clothing from waist down removed and dressed in a gown

TM 8-280 pp. 10-79 Figure 10-73

1073

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*LP 38-520-076
076

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

Positioning Additional Views: Sacroiliac Articulation, Lumbar and Dorsal Spine (1 hour)

COURSES PRESENTED TO: Radiographic Procedures (Basic), 313-91P20

PLACE: Classroom

REFERENCES:

TM 8-280, pp 10-74, 10-77, and 10-80.
Merrill, Vinita. Atlas of Roentgenographic Positions. 3d ed., Vol. I. St. Louis, Missouri: C.V. Mosby Company, 1967, pp 208-217, 240-261.

STUDY ASSIGNMENT: After class study GR 38-520-027-1B and TM 8-280, pp 10-74, 10-77, and 10-80.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 and GR 38-520-027-1B.

TOOLS, EQUIPMENT, AND MATERIALS: GR 38-520-027-1B issued at beginning of seventh week.

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Radiographs of the oblique sacroiliac articulation, lumbar and dorsal spine; x-ray illuminators, pointer; chalkboard, chalk and eraser; PA system with lapel mike (see Annexes A thru C)

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

I. INTRODUCTION (5 min)

A. Opening Statement: Let us suppose we are all assigned to a permanent duty station and it is that time of year again--ANNUAL PHYSICAL FITNESS TEST! Now, when it is time for the gang to have PT, where is that buddy of yours? He is lying on his back in bed with a profile, and it only bothers him when something has to be done. This is the time when you wish you were the X-Ray Specialist who took those films. Good films, so he could not keep on sandbagging.

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*This lesson plan supersedes LP 38-520-076, 055.

1074

B. Objectives

1. Identify by name the position and anatomical structures demonstrated of the oblique SI, oblique lumbar and dorsal spine.

2. State the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization film identification and captioning necessary to demonstrate the position(s) of the SI, oblique lumbar and dorsal spine.

3. Given a request slip and a simulated patient in the x-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiograph(s) of the SI, oblique lumbar and dorsal spine.

C. Class Procedure and Lesson Tie-in

1. Students will gather around the x-ray table during the demonstration.

2. Students will be demonstrating these positions in their laboratory practical exercise on crucial objectives.

II. DEMONSTRATION (35 min)

A. Anatomical Structures Demonstrated -- Oblique SI, Oblique Lumbar and Dorsal Spine

NOTE: Place radiographs on view box and point out the following anatomical structures:

1. Thoracic vertebrae
   a. Articular processes
   b. Apophyseal articulations
2. Lumbar vertebrae
   a. Articular processes
   b. Apophyseal articulations
3. Sacroiliac joint

B. Positions

1075

NOTE: Refer to Annex A thru C for explanation of positions and have the students fill in their GR's.

1. Oblique Dorsal Vertebrae (additional)

NOTE: From the lateral position rotate the trunk backwards until coronal plane forms 70 degree angle with the table top.

EMPHASIZE: That coronal plane for spine positions is determined by using the acromion process and the superior prominence of the iliac crest.

NOTE: Patient is in an RPO or LPO position.

NOTE: Immobilization by placing angled positioning sponge posterior to body, and have patient grasp table edge, posterior to body with hand of elevated side to aid in comfort.

QUESTION: What is the PFR for RPO dorsal position?

ANSWER: Acromion processes 3 inches below upper film border.

2. Oblique lumbar vertebrae (additional)

NOTE: Patient is in an RPO or LPO position.

QUESTION: What is the alignment for oblique lumbar?

ANSWER: Coronal plane 45 degree to table, spine centered.

3. Oblique sacroiliac articulations (routine)

NOTE: Patient is in an RPO or LPO position.

QUESTION: What is the angle and direction of CR for oblique SI?

ANSWER: Vertical perpendicular to center of film.

C. Demonstrate positions using information in Annexes A thru C.

NOTE: Position will be demonstrated by the instructor using a student from the class as a patient and refer students to the order of procedure.

NOTE: Instructor emphasize importance of patient being dressed in dressing gown for this procedure.

1077

D. Questions From Students

NOTE: Make study assignment: After class study TM 8-280, pp 10-74, 10-77, and 10-80 and GR 38-520-027-1B.

III. SUMMARY (5 min)

A. Review of Main Points

1. Anatomical Structures

2. Positions

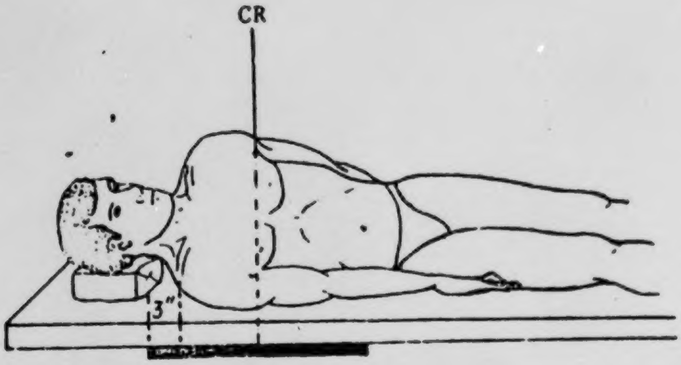
3. Demonstration

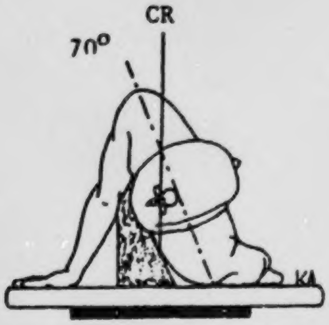
B. Closing Statement: Remember that even though these positions may be considered special views, they are taken routinely in many Army clinics. Correct alignment and centering as your guidelines will enable you to take a diagnostic radiograph of these views.

ANNEX A
INSTRUCTIONAL AIDS

Oblique Dorsal

Routine: AP and Lateral





Dorsal Spine Position Oblique (RPO and LPO)

PFR: Plane thru Acromion Process 3" below upper border of the film holder

Film Rundown: 14 x 17, L W, B ID: Either lateral border

CR: V P Cone: FFC

Coronal plane 70° from table

Alignment: adjust spine to center line of table

Breathing Technique: Suspended Excirati[illegible] for uniform density FFD: 40 "

Demonstrates: Dorsal spine with emph[illegible]is on apophyseal joints and articular processes

Notes: 1. From true lateral rotate patient backwards until Coronal plane forms a 70° angle with table.

2. IMMOBILIZATION: Use sponge positioning blocks for buttressing material

3. Elevated arm is posterior behind patients back

4. Patient Dress: Clothing from waist up removed and patient dressed in gown

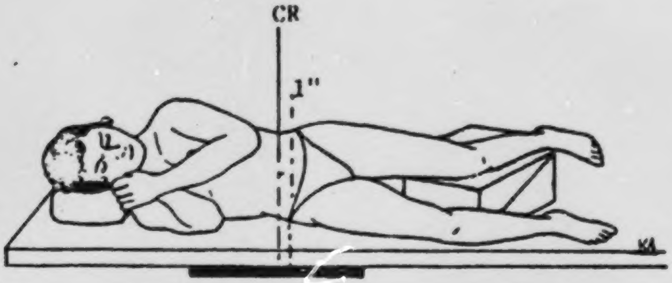
5. Side away from film is best demonstrated

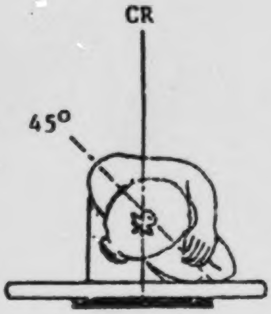
6. Both obliques are taken

076 1078

INSTRUCTIONAL AIDS
Oblique Lumbar

Routine: AP and Lateral





Lumbar Spine Position Oblique (LPO and RPO)

PFR: Plane thru Superior Prominence of Iliac Crests 1 " below center of film holder

Film Rundown: 14 x 17, L W, B ID: Either lateral border

CR: V P Cone: FFC

Alignment: Coronal Plane 45° to table, adjust spine over center line of table

Breathing Technique: Suspended Respiration for immobilization FFD: 40 "

Demonstrates: Apophyseal Joints and Articular Processes closest to film

Notes: 1. Both obliques are taken

2. To immobilize patient, use sponge positioning blocks for buttressing material

3. Patient Dress: Remove clothing from the waist down and dressed in gown

1079

ANNEX C
INSTRUCTIONAL AIDS

LP 38-520-076
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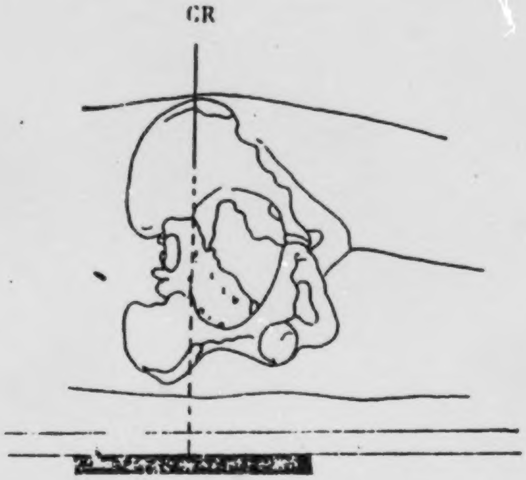
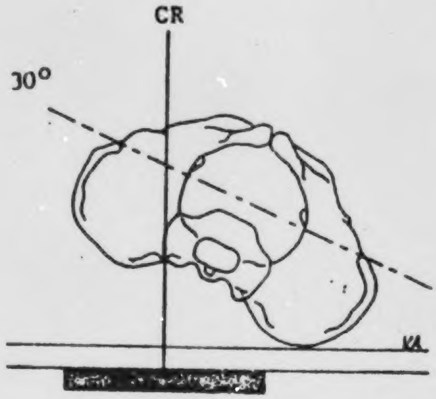
Oblique Sacroiliac Articulation

Routine: Bilateral





Sacroiliac Articulation Position Oblique (RPO and LPO)

PFR: A point 1" medial of the elevated ASIS to center of film holder

Film Rundown: 10 x 12, L W, B ID: Either lateral border within conefield

CR: V P Cone: 8 "

Alignment: Coronal plane rotated 30° oblique. Hips and shoulders in same plane.

Breathing Technique: Suspended Respiration FFD: 40 "

Demonstrates: Sacroiliac Articulation (Elevated Side)

Notes: 1. Buttress patient using sponge blocks

2. Both sides are taken for comparison

3. Patient Dress: Clothing from waist down removed and dressed in gown

1080

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LP 38-520-054
076

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

Positioning of the Trunk: Chest (2 hours)

COURSES PRESENTED TO: Radiographic Procedures (Basic), 313-91P20

PLACE: Classroom

REFERENCES:

TM 8-280, pp 10-52 thru 10-55.
Merrill, Vinita. Atlas of Roentgenographic Positions. 3d ed. Vol. I. St. Louis: C.V. Mosby Company, 1967, pp 560-569.

STUDY ASSIGNMENT: After class study GR 38-520-027-1B and TM 8-280, pp 10-52 thru 10-55.

STUDENT UNIFORM AND EQUIPMENT: TM 2-280 and GR 38-520-027-1B.

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Radiographs of the chest, pointer, and x-ray illuminator; chalkboard, chalk, and eraser; skeleton; diagrams of chest, PA system with lapel mike (see Annexes A through D)

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

I. INTRODUCTION (5 min)

A. Opening Statement: Radiographs of the chest make up 80% of your clinic's workload. In almost any X-ray clinic, you are going to find that one room has been set aside for the purpose of chest work. With this large percentage of the workload being devoted to the chest, it is extremely important that the X-ray Specialist knows, and uses, the proper positioning to produce consistently high quality diagnostic radiographs.

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*This lesson plan supersedes LP 38-520-054, 094.

1081

B. Objectives

1. Identify by name the positions and anatomical structures demonstrated of the routine and additional views of the chest.

2. State the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central fay, FFD, alignment, breathing technique, immobilization, film identification and captioning necessary to demonstrate the position(s) of the routine and additional views of the chest.

3. Given a request slip and a simulated patient in the x-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiograph(s) of the routine and additional views of the chest.

C. Class Procedure and Lesson Tie-in

1. Students will gather around x-ray table during the demonstration.

2. Students will be demonstrating these positions in their laboratory practical exercise on crucial objectives.

II. DEMONSTRATION (80 min)

A. Anatomical Structures Demonstrated -- Chest

NOTE: Use skeleton to point out the following:

1. Complete spine

2. Shoulder girdle

   a. Scapulae

   b. Clavicles

3. Ribs

4. Area of heart and mediastinum

5. Area of diaphragm

6. Area of lungs

NOTE: Place radiographs of PA chest on the viewbox and point out the following:

a. Borders

(1) Lateral (costal)

(2) Bottom (diaphragmatic or phrenic)

(3) Medial

b. Angle--costophrenic

c. Apex (apices)

d. Mediastinal area

e. Lobes (five)

f. Diaphragm

QUESTION: What is the name of the point where the coastal margin and the phrenic angle meet?

ANSWER: Costophrenic angle.

B. Positions

NOTE: Refer to Annex A thru D for explanation of positions and have the students fill in their GR's.

1. PA (routine)

NOTE: When practical, you should have the patient take a deep breath, exhale, take another deep breath, and take the film after the second full inspiration. The patient will get more air in the lungs by doing it this way.

2. Lateral (additional view)

QUESTION: What is the film rundown for the PA chest?

ANSWER: 14 by 17, lengthwise, non-Bucky.

QUESTION: How many lobes are there in the lungs?

ANSWER: Five.

QUESTION: What is the FFD for the PA chest?

ANSWER: 72 inches.

LP 38-520-054
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QUESTION: What is the FFD for the lateral chest?

ANSWER: 72 inches.

3. Obliques (additional views)

Right anterior oblique (RAO) and Left anterior oblique (LAO)

NOTE: Posterior obliques are seldom performed.

QUESTION: Which lung field is best demonstrated on the RAO view of the chest?

ANSWER: The left lung field.

4. Lordotic (additional)

NOTE: The lordotic view of the chest is taken to demonstrate the apices of the lungs.

C. Demonstrate positions using information in Annexes A thru D.

NOTE: Positions will be demonstrated by the instructor using a student from the class as a patient and refer students to the order of procedure.

QUESTION: What is the PFR for the lordotic chest?

ANSWER: Acromion processes 5 inches below the top border of the film holder.

QUESTION: What is the breathing technique for all chest views?

ANSWER: Suspended inspiration after second deep breath.

D. Questions From Students

NOTE: Make study assignment: After class study TM 8-280, pp 10-52 thru 10-55 and GR 38-520-027-1B.

III. SUMMARY (5 min)

A. Review of Main Points

1. Anatomical structures

2. Positions

3. Demonstration

B. Closing Statement: If you are given a request slip for the routine chest, only one film is required; this will be the posteroanterior chest. But always keep in mind that there are numerous additional views. Any additional view that is needed will be determined by the Radiologist. It is your job as an X-Ray Specialist to be able to properly position all of the chest views and to have a thorough knowledge of why these views are being requested.

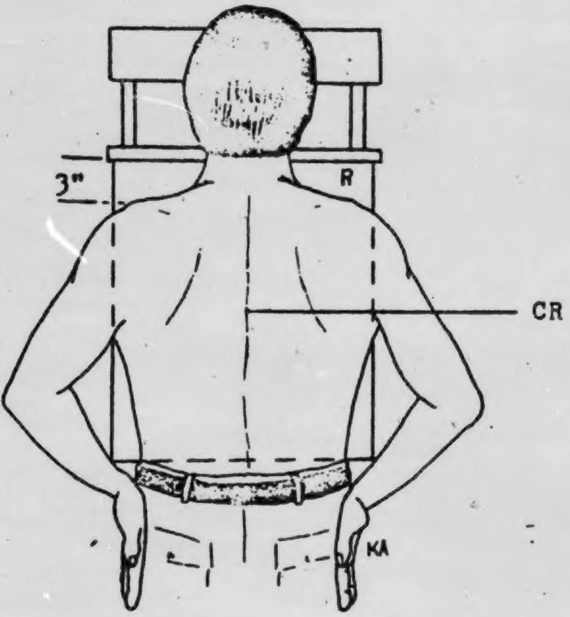
076 1085

INSTRUCTIONAL AIDS

Chest

Routine: PA

Additional: Lateral, Oblique, and Lordotic



Chest Position P A

PFR: Acromion Process 3" below upper border of film holder

Film Rundown: 14 x 17, L W, NB ID: Above shoulder reading down

CR: H P Cone: FFC

Alignment: Median Plane perpendicular and over center line of film

Breathing Technique: Suspended Inspiration after second (2) deep breath FFD: 72 "

Demonstrates: Lungs, heart, aorta; secondarily ribs

Notes:

1. Part-to-Film reference is made prior to the patient placing hands on hips.
2. Back of hands are placed on hips, shoulders and elbows are rotated as far forward as possible to remove the Scapula from the lung fields.
3. 72" FFD is used to minimize magnification of the heart shadow.
4. Patient Dress: Male Patients:- clothing from waist up removed

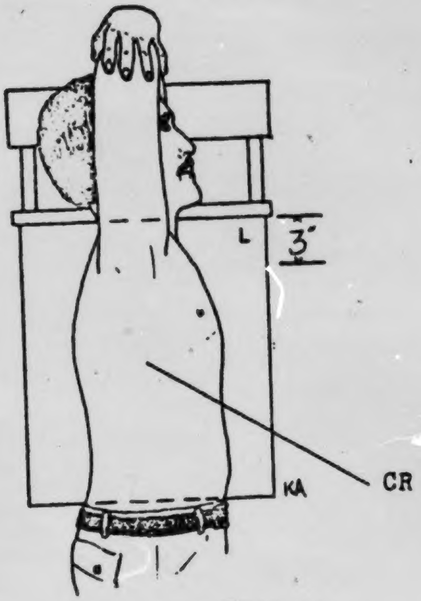
   Female Patients;- dressed in gown after removing clothing from waist up

INSTRUCTIONAL AIDS

Chest

Routine: PA

Additional: Lateral Oblique, and Lordotic



Chest Position Lateral

PFR: Plane thru Acromion Process 3" below upper border of film holder

Film Rundown: 14 x 17, L W, NB ID: Upper border anterior to part

CR: H P Cone: FFC

Alignment: Median Plane parallel to film and trunk centered

Breathing Technique: Suspended Inspiration after second deep breath FFD: 72 "

Demonstrates: Lungs, heart, aorta, interlobar fissures, mediastinum

Notes: 1. Arms up and folded over head.

2. Lung field closest to film is best demonstrated

3. Patient Dress: Male: Clothing from waist up removed
Female: Dressed in gown after removing clothing from waist up

4. The left lateral is preferred, because of less magnification of the heart, due to Object Film Distance (OFD)

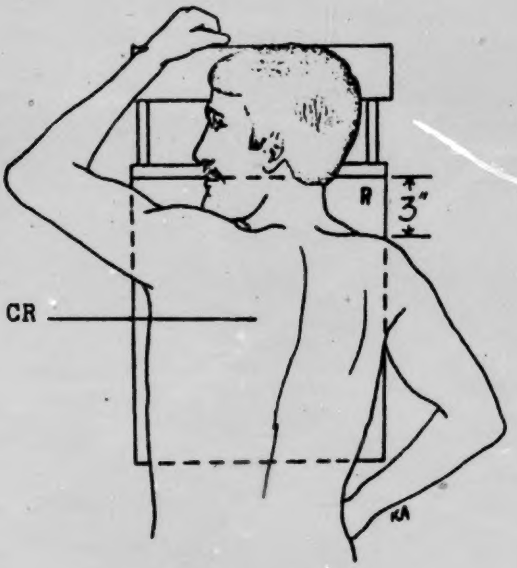
TM 8-280 pp. 10-53 Figure 10-48

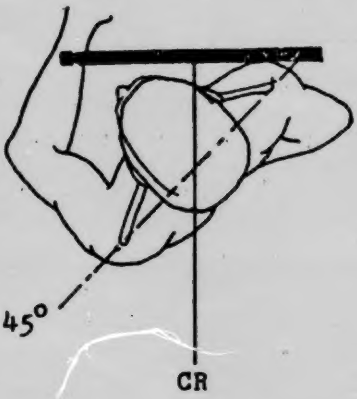
INSTRUCTIONAL AIDS

Chest

Routine: PA

Additional: Lateral, Oblique, and Lordotic





Chest Position Oblique (RAO and LAO)

PFR: Acromion Process 3" below upper border of film holder

Film Rundown: 14 x 17, L W, NB ID: Above part reading down

CR: H P Cone: FFC

Alignment: Trunk centered, Coronal Plane 45^{b} to film

Breathing Technique: Suspended Inspiration after second (2) deep breath FFD: 72"

Demonstrates: Best demonstrates lung field furthest from film

Notes: 1. Both obliques of the chest are normally taken, when a full study of the chest area is required.

2. Patient Dress: Male: Clothing removed from waist up

Female: Dressed in gown after removing clothing from waist up

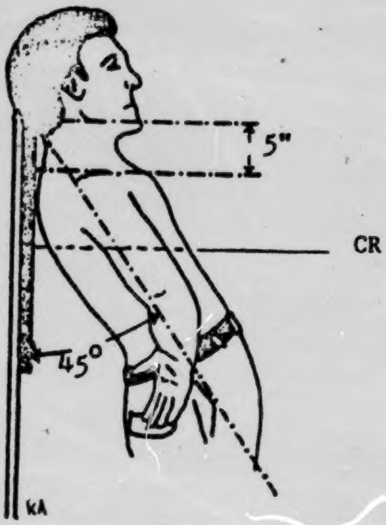
TM 8-280 pp. 10-54 Figure 10-49

1088

Chest

Routine: PA

Additional: Lateral, Oblique, and Lordotic



Chest Position Lordotic

PFR: Acromion Processes 5" below upper border of film holder

Film Rundown: 14 x 17, L W, NB ID: Above part reading down

CR: H P Cone: FFC

Alignment: Trunk centered, with Coronal Plane forming a 45° angle with the film

Breathing Technique: Suspended Inspiration after second (2) deep breath FFD: 72"

Demonstrates: Apices of lungs

Notes: 1. For patient safety, have patient remove high heel shoes

2. Place backs of hands on hips, rotate shoulders and elbows forward to remove Scapula from lung fields.

3. Patient Dress: MALE: Remove clothing from the waist up
FEMALE: Dressed in gown after removing clothing from waist up

TM 8-280 pp 10-55 Figure 10-50

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*LP 38-520-055
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X-RAY BRANCH

Positioning of the Trunk: Ribs (2 hours)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES:

TM 8-280, pp 10-59 through 10-60
Merrill, Vinita. Atlas of Roentgenographic Positions. 3d ed.
St Louis, Missouri: The C. V. Mosby Company, 1967, pp 164-172

STUDY ASSIGNMENT: After class study GR 38-520-027-1B and TM 8-280, pp 10-59 through 10-60.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 and GR 38-520-027-1B

TOOLS, EQUIPMENT AND MATERIALS: GR 38-520-027-1B issued at beginning of seventh week.

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Radiographs of the ribs; skeleton; pointer; and X-Ray illuminator; chalkboard, chalk, and eraser; PA system with lapel mike (see Annexes A through E).

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

I. INTRODUCTION (3 min)

A. Opening Statement: Rib injuries are usually very painful and they sometimes cause breathing difficulties. Extreme caution must be taken to protect the patient from unnecessary discomfort and further injury.

B. Objectives

1. Identify by name the position and anatomical structures demonstrated of the routine and additional views of the ribs.

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*This lesson plan supersedes LP 75-520-055, 094

1090

2. State the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization, film identification and captioning necessary to demonstrate the position(s) of the routine and additional views of ribs.

3. Given a request slip and a simulated patient in the X-ray laboratory select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiograph(s) of the routine and additional views of the ribs.

C. Class Procedure and Lesson Tie-in

1. Students will gather around the X-Ray table during the demonstration.

2. Students will be demonstrating these positions in their laboratory practical exercise on crucial objectives.

II. DEMONSTRATION (88 min)

A. Anatomical Structures Demonstrated - Ribs

NOTE: Place radiographs on viewbox and point out the following anatomical structures.

1. Heart
2. Lungs
3. Diaphragm
4. Acromion processes
5. Iliac crest
6. Spine (dorsal)
7. Ribs
    a. Seven true (pairs) or sternal ribs
    b. Five false (pairs) or asternal ribs

NOTE: Three pairs of false ribs are attached by cartilage to the seventh ribs, and are called the vertebrochondral ribs. Two pairs are called floating or vertebral ribs.

NOTE: When injury is of ribs 1 through 8, the above the diaphragm routine will be taken. For 9 through 12, the below the diaphragm routine will be taken

QUESTION: How many pairs of true ribs are there?

ANSWER: Seven pairs.

B. Positions

NOTE: Refer to Annexes A through E for explanation of positions and have the students fill in their GR's.

1. Ribs above diaphragm

NOTE: Explain use of table show in Annex A.

NOTE: All ribs above diaphragm are done erect for patient comfort

2. Obliques above diaphragm (RAO, LAO, or RPO, LPO)

3. Ribs below diaphragm

NOTE: All ribs below the diaphragm are done erect.

4. Obliques below diaphragm (RPO & LPO)

C. Demonstrate positions using information in Annexes A through E.

NOTE: Positions will be demonstrated by the instructor using a student from the class as a patient and refer students to the order of procedure.

NOTE: Refer students to PA chest positions in GR 38-520-027-1B

QUESTION: When the injury is above the xiphoid, what is the PFR?

ANSWER: Acromion process three inches below the upper film border.

QUESTION: What rib area is best demonstrated by the left anterior oblique?

ANSWER: Right anterior ribs.

QUESTION: What is the breathing technique for ribs below the diaphragm?

ANSWER: Suspended expiration.

D. Questions from Students

NOTE: Make study assignment: After class read TM 8-280, pp 10-59 through 10-60 and GR 38-520-027-1B

1093

III. SUMMARY (5 min)

A. Review of Main Points

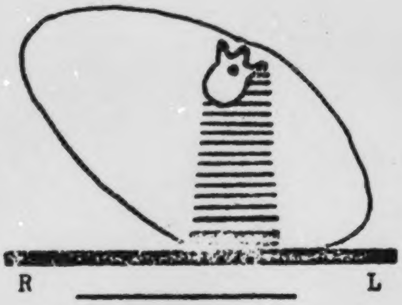
1. Anatomy

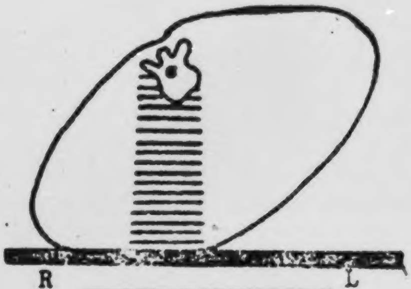
2. Positions

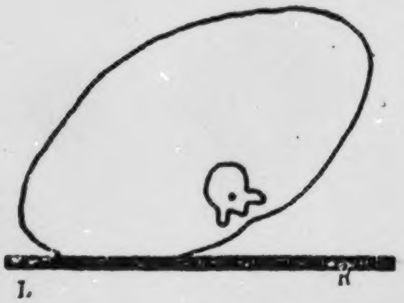
B. Closing Statement: Injuries to the ribs may result from many types of accidents--vehicle accidents, troop training accidents, or combat hazards. As future X-ray Specialists you are expected to correctly position the rib routines.

INSTRUCTIONAL AIDS
TABLE OF OBLIQUE RIBS

RIB POSITION	DEMONSTRATES	
	ABOVE THE DIAPHRAGM	BELOW THE DIAPHRAGM
LAO 30°	RIGHT ANTERIOR RIBS	N/A
RAO 30°	LEFT ANTERIOR RIBS	N/A
LPO 30°	LEFT POSTERIOR RIBS	LEFT POSTERIOR RIBS
RPO 30°	RIGHT POSTERIOR RIBS	RIGHT POSTERIOR RIBS







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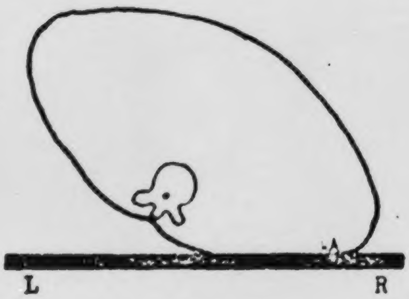
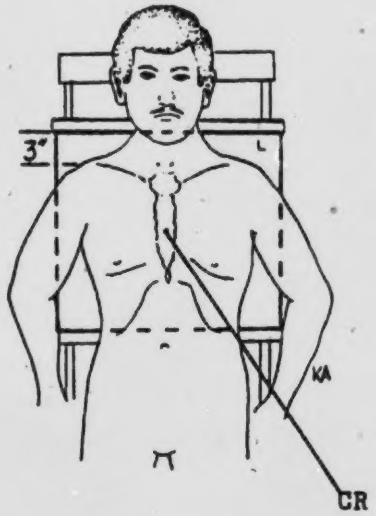


ANNEX B
INSTRUCTIONAL AIDS
RIBS

Rib Routine: PA Chest, AP OR PA RIBS, OBLIQUE FOR INJURY



Ribs above diaphragm Position AP or PA

PFR: Plane through Acromion processes 3" below the upper film border

Film Rundown: 14 x 17 CW B ID: Above either shoulder

CR: Horizontal Perpendicular Cone: Full film coverage

Alignment: Patient upright, Median plane perpendicular and centered to film

Breathing Technique: Suspended Inspiration FFD: 40"

Demonstrates: Ribs above diaphragm and costalvertebral articulations.

Notes: 1. Rib injuries above the diaphragm, use suspended inspiration to lower the diaphragm.

2. The patient will remove all clothing and jewelry above the waist.

3. Patient Dress: Male patients remove all clothing above the waist Female patients dressed in a gown after removing clothing from waist up.

4. AP or PA view is done as a general survey film.

TM 8-280 pp 10-59 Fig 10-53

Injured Area ANNEX C _ INSTRUCTIONAL AIDS
RIBS

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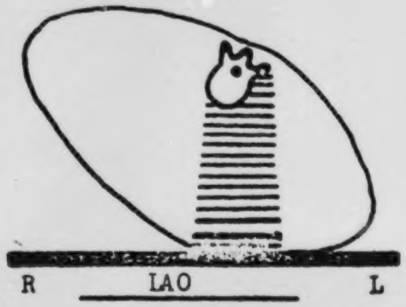
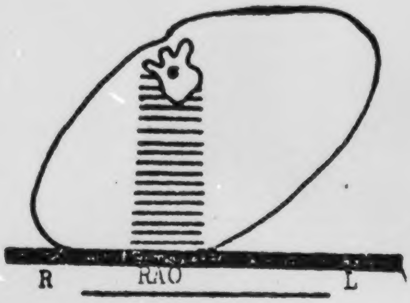
Anterior above: PA Chest, PA Ribs, Oblique for Injury

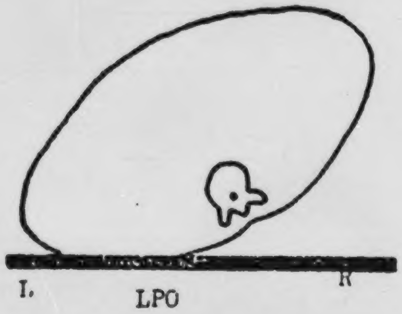
Posterior above: PA Chest, AP Ribs, Oblique for Injury



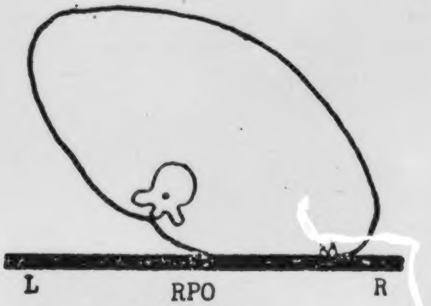
LAO



RAO



LPO



RPO

Oblique ribs Positions Above the diaphragm

PFR: Plane through Acromion processes 3" below the upper border of film holder.

Film Rundown: 14 x 17 CW B ID: Above either shoulder and to correspond with correct side of patient

CR: Horizontal Perpendicular Cone: Full film coverage

Alignment: Trunk centered, coronal plane obliqued 30°, patient upright

Breathing Technique: Suspended Inspiration FFD: 40"

Demonstrates: Ribs at site of injury: RAO-left anterior ribs; LAO- right anterior ribs; RPO-right posterior ribs; LPO-left posterior ribs

Notes: 1. Anterior obliques demonstrate side away from film.

2. Posterior obliques demonstrate side closest to film.

3. A single oblique of side under consideration is taken.

4. Patient dress; Same as chest 1097

TM8-280 pp10-60 Fig 10-54

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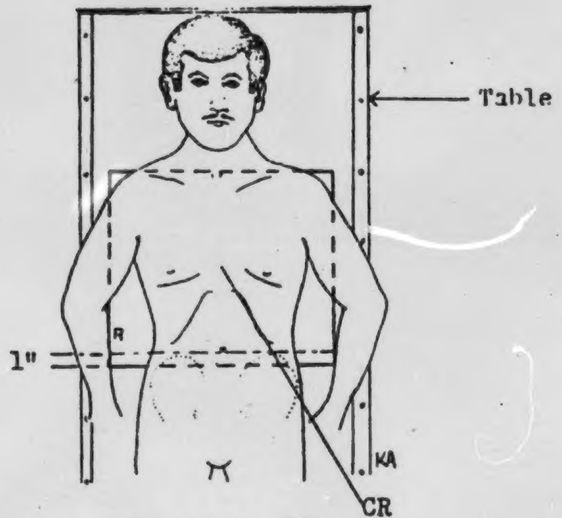
INSTRUCTIONAL AIDS
RIBS

/ Rib Routine: PA Chest, AP Ribs, Oblique for injury



Ribs Below Diaphragm. Position AP

PFR: Iliac crests 1" above the lower film border

Film Rundown: 14 x 17, C W, B ID: Either lateral border

CR: H P Cone: FFC

Alignment: Patient erect, Median plane centered

Breathing Technique: Suspended Expiration

Demonstrates: Ribs below diaphragm FFD: 40"

Notes: 1. Suspended expiration is used to raise the diaphragm

2. The AP view is always done as a general survey film

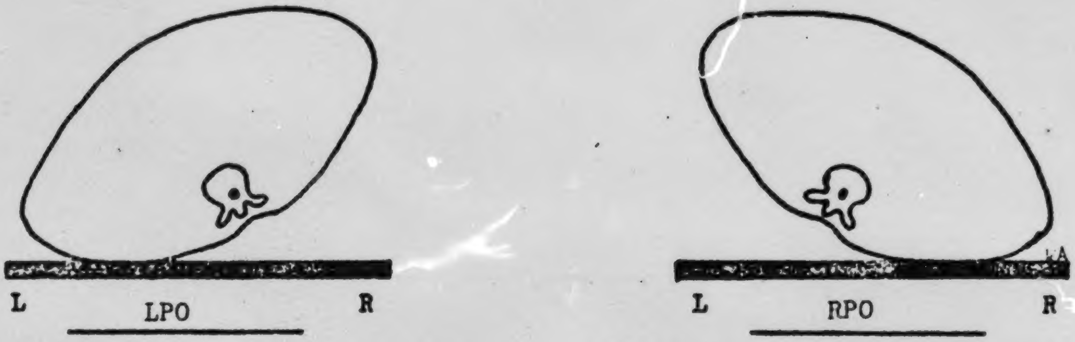
3. Patient's dress; Same as AP or PA

TM8-280 pp 10-59 Fig 10-53

RIBS

1097

Rib Routine: PA Chest, AP Ribs, Oblique for injury



Oblique Rib Positions Below the diaphragm

PFR: Plane through Iliac crests 1" above the lower film border

Film Rundown: 14 x 17 CW B ID: Either lateral border to correspond with correct side of patient

CR: Horizontal Perpendicular Cone: Full film coverage

Alignment: Patient erect, Trunk centered, coronal plane rotated 30°

FFD: 40"

Breathing Technique: Suspended expiration

Demonstrates: Site of injury; LPO-Left posterior ribs, RPO-Right posterior ribs

Notes: 1. LPO and RPO demonstrate the posterior ribs that are closest to the film.

2. Patient's dress: Same as chest

TM8-280 pp 10-60 Fig 10-54

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*LP 38-520-056
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ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

Positioning of the Trunk: Abdomen (1 hour)

COURSES PRESENTED TO: Radiographic Procedures (Basic), 313-91P20

PLACE: Classroom

REFERENCES:

TM 8-280, pp 10-64 through 10-65.
Merrill, Vinita. Atlas of Roentgenographic Positions. 3d ed, Vol III St. Louis, Mo.: C. V. Mosby Co, 1967, pp 583, 588

STUDY ASSIGNMENT: After class study GR 38-520-027-1B and TM 8-280, pp 10-64 through 10-65.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 and GR 38-520-027-1B

TOOLS, EQUIPMENT, AND MATERIALS: GR 38-520-027-1B issued at beginning of seventh week.

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Radiographs of the abdomen; pointer and X-ray illuminator; chalk, chalkboard, and eraser; PA system with lapel mike. (See Annexes A through C)

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

I. INTRODUCTION (2 min)

A. Opening Statement: In an X-ray clinic you will frequently be called upon to position the routine abdomen and the additional views demonstrating various organs within the abdomen. The routine abdomen is mainly taken as a survey film. The additional views demonstrate herniation of the diaphragm, stones, obstructions within the organs, and free air under the diaphragm. As future X-Ray Specialists, you must understand what pathology the radiologist is looking for in order to perform the correct examination.

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*This lesson plan supersedes LP 38-520-05^{6}0, 094

1099

B. Objectives

1. Identify by name the position and anatomical structures demonstrated of the routine and additional views of the abdomen.

2. State the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization, film identification and captioning necessary to demonstrate the position(s) of the routine and additional views of the abdomen.

3. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiograph(s) of the routine and additional views of the abdomen.

C. Class Procedure and Lesson Tie-in

1. Students will gather around the X-ray table during the demonstration.

2. Students will be demonstrating these positions in their laboratory practical exercise on crucial objectives.

II. DEMONSTRATION (40 min)

A. Anatomical Structures Demonstrated - Abdomen

NOTE: Place radiographs on viewbox and point out the following anatomical structures.

1. Pelvis

a. Iliac crest

b. Symphysis pubis

2. Spine

3. Diaphragm

4. Xiphoid process

5. Abdominal cavity

a. Urinary system

(1) Kidneys

1101

(2) Ureters

(3) Bladder

NOTE: Another name for the AP abdomen is KUB.

QUESTION: What are the organs of the urinary system that may be seen on a radiograph of the abdomen?

ANSWER: Kidneys, ureters, and bladder.

B. Positions

NOTE: Refer to Annexes A through C for explanation of positions and have the students fill in their GR's.

1. AP Abdomen (routine)
2. Upright Abdomen (additional view)
3. Upright KUB (additional view)

C. Demonstrate Positions using information in Annexes A through C.

NOTE: Position will be demonstrated by the instructor using a student from the class as a patient and refer students to the order of procedure.

QUESTION: What is the PFR for the AP view of the abdomen?

ANSWER: Plane through superior prominence of iliac crests to center of film holder.

QUESTION: What is the film rundown for the AP view of the abdomen?

ANSWER: 14 x 17, lengthwise, Bucky.

NOTE: Clarify central ray relationship to film when patient is in the semi-upright position; it is always directed horizontal to the patient.

NOTE: The upright abdomen is taken to demonstrate free air under the diaphragm and fluid levels.

QUESTION: What does the upright abdomen demonstrate besides the Viscera?

ANSWER: Free air under the diaphragm and fluid levels.

D. Questions from Students

NOTE: Make study assignment: After class study TM 8-280, pp 10-64 through 10-65, and GR 38-520-027-1B.

1101

III. SUMMARY (3 min)

A. Review of Main Points

1. Anatomical Structures

2. Position

3. Demonstration

B. Closing Statement: The abdomen contains many organs which may cause a wide variety of complications through trauma and disease. Therefore, the responsibility of producing diagnostic radiographs is going to be yours. In many cases the medical officer will order an abdominal examination before he starts any further procedures. Keeping this in mind, you must be able to produce diagnostic radiographs the first time. You may not have time to repeat this examination before the patient starts treatment.

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ANNEX A
INSTRUCTIONAL AIDS

LP 38-520-056
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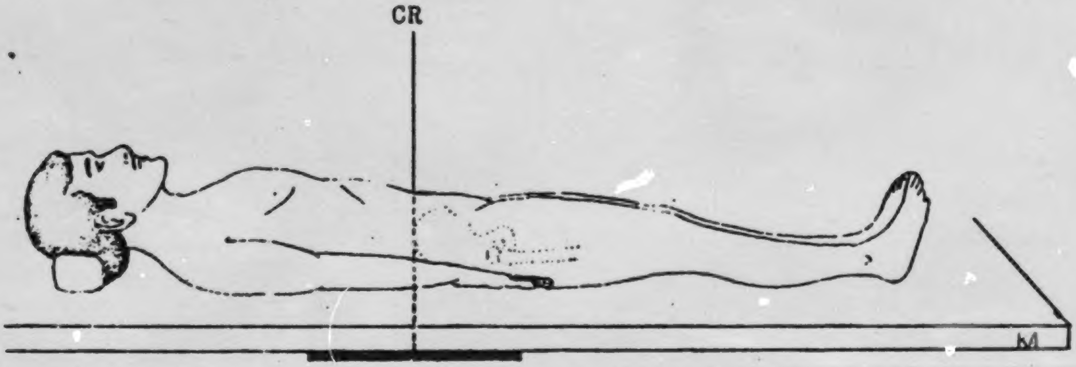
Abdomen

Routine: AP

Additional: Upright



Abdomen (KUB) Position AP

PFR: Plane thru Superior Prominence of Iliac Crest to center of film holder

Film Rundown: 14 x 17, L W, B ID: Either lateral border

CR: V P Cone: FFC

Alignment: Median Plane perpendicular and over center line of table

Breathing Technique: Suspended Expiration FFD: 40 "

Demonstrates: The internal viscera

Notes: 1. This is a survey film of the abdomen from the Symphysis Pubis to the diaphragm. It is frequently called a KUB (kidneys, ureters, and bladder)

2. Patient Dress: Clothing removed and dressed in a gown.

3. Suspended Expiration to control peristaltic motion of the viscera

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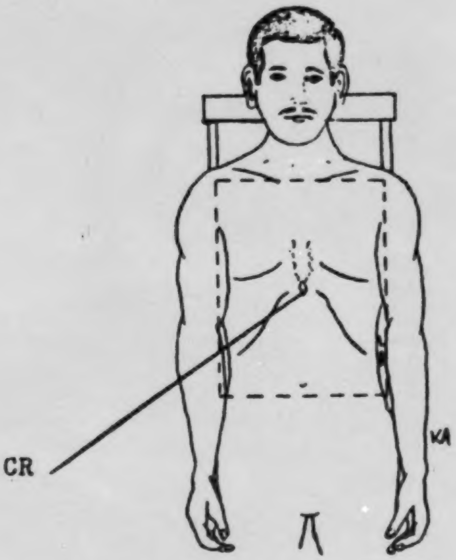
TM 8-280 pp. 10-64 Figure 10-58

INSTRUCTIONAL AIDS
Abdomen

Routine: AP

Additional: Upright



Abdomen Position Upright

PFR: Xiphoid Process to center of film holder

Film Rundown: 14 x 17, L W, B ID: Either lateral border

CR: H P Cone: FFC

Alignment: Median Plane perpendicular and over center line of table

Breathing Technique: Suspended Expiration FFD: 40 "

Demonstrates: Diaphragm, Lower Lungs and internal viscera

Notes: 1. Also aids in demonstrating fluid levels and free air under the diaphragm

2. To demonstrate fluid levels and free air the CR must always be directed Horizontal.

3. An upright marker must be used with the side letter marker

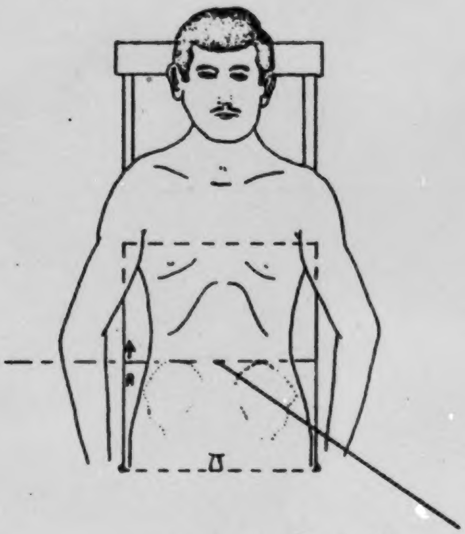
4. Patient Dress: same as AP

TM 8-280 pp. 10-65 Figure 10-59

ANNEX C
INSTRUCTIONAL AIDS
Abdomen

Routine: AP

Additional: Upright KUB



KUB Position Upright

PFR: Plane thru Superior Prominence of Iliac Crests to center of film holder

Film Rundown: 14 x 17, L W, B ID: Either lateral border

CR: H P Cone: FFC

Alignment: Median Plane perpendicular and over center line of table

Breathing Technique: Suspended Expiration FFD: 40 "

Demonstrates: Kidneys, ureters and urinary bladder

Notes: 1. An upright marker must be used with the side letter marker

2. Patient Dress: Clothing removed and dressed in a gown

TM 8-280 pp. 10-64 Figure 10-58

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DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

Positioning: Sternum (1 hour)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES:

TM 8-280, pp 10-61 and 10-62.
Merrill, Vinita. Atlas of Roentgenographic Positions. 3d ed. Vol. I. St. Louis: C.V. Mosby Company, 1967, pp 152-159.

STUDY ASSIGNMENT: After class study GR 38-520-027-1B and TM 8-280, pp 10-61 and 10-62.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 and GR 38-520-027-1B.

TOOLS, EQUIPMENT, AND MATERIALS: GR 38-520-027-1B issued at beginning of seventh week.

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Radiographs of the sternum, x-ray illuminator, pointer; chalkboard, chalk, and eraser; PA system with lapel mike (see Annexes A and B)

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

I. INTRODUCTION (2 min)

A. Opening Statement: The examination of the sternum is unique because it is one of the few radiographic procedures where motion is desired during the exposure. The motion blurs out the vascular markings which can obscure the sternum. While this procedure is not unduly difficult, it can present a challenge to any x-ray specialist because of the various anatomical structures that may de-emphasize the sternum when radiographed improperly.

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*This lesson plan supersedes LP 38-520-072, 034.

1106

B. Objectives

1. Identify by name the positions and anatomical structures demonstrated of the routine sternum.

2. State the correct routine, PFR/CRPR, film fundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization, film identification and captioning necessary to demonstrate the position(s) of the routine sternum.

3. Given a request slip and a simulated patient in the x-ray laboratory, select the proper technical factors, accessory equipment, and the correct positioning data which would produce technically acceptable radiograph(s) of the routine sternum.

C. Class Procedure and Lesson Tie-in

1. Students will gather around the x-ray table during the demonstration.

2. Students will be demonstrating these positions in their laboratory practical exercise on crucial objectives.

II. DEMONSTRATION (40 min)

A. Anatomical Structures Demonstrated -- Sternum

NOTE: Place radiographs on illuminator and point out the following anatomical structures.

1. Heart
2. Ribs
3. Clavicle
4. Sternoclavicular articulation (joint)
5. Spine (dorsal)
6. Sternum
    - a. Manubrial notch
    - b. Manubrium
    - c. Sternal angle (or angle of Louis)
    - d. Body of the sternum
    - e. Xiphoid process

1108

B. Positions

NOTE: Refer to Annexes A and B for explanation of positions and have the students fill in their GR's.

1. RAO--sternum (routine)
2. Lateral sternum (routine)

NOTE: The patient will be upright, using a cassette changer or holder.

C. Demonstrate positions using information in Annexes A and B.

NOTE: Positions will be demonstrated by instructor using a student as a patient and refer students to the order of procedure.

QUESTION: What is the breathing technique used for PARO sternum and why is it used?

ANSWER: Normal breathing to blur vascular markings.

QUESTION: What is the position of the patient for the lateral sternum projection?

ANSWER: Upright.

D. Questions From Students

NOTE: Make study assignment: After class study TM 8-280, pp 10-61 and 10-62 and GR 38-520-027-1B.

III. SUMMARY (3 min)

A. Review of Main Points

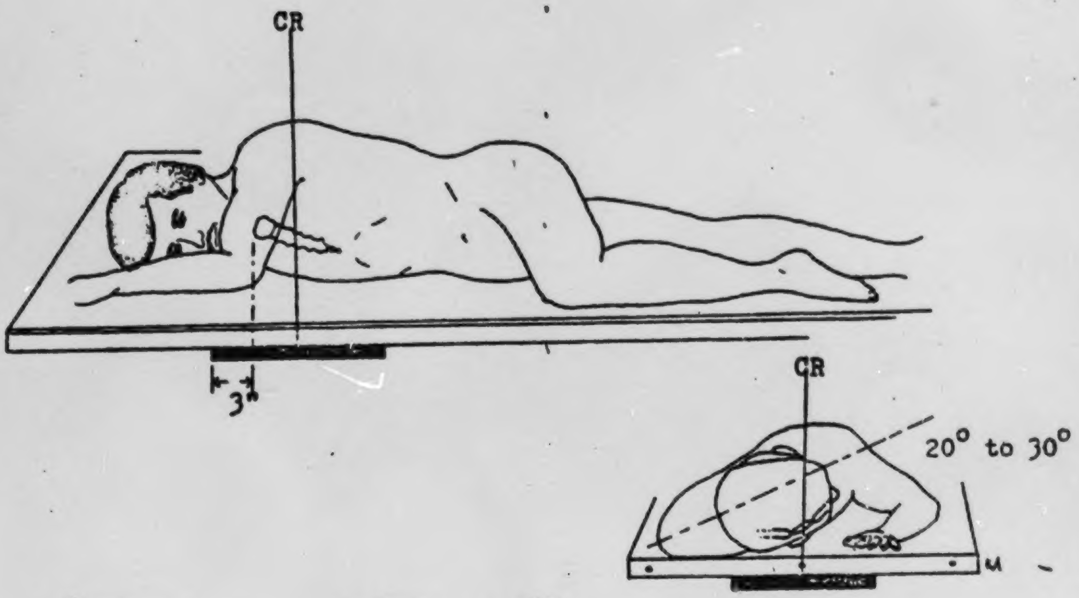
1. Anatomical Structures
2. Positions
3. Demonstration

B. Closing Statement: One of the sternum's principle functions is to protect the heart. Since this is a protective structure, extreme care must be used while working with a patient who has a possible fracture of the sternum or of the sternoclavicular articulations to do this procedure correctly the first time.

1108

ANNEX A
INSTRUCTIONAL AIDS
Sternum

Routine: RAO and Lateral



Sternum Position RAO

PFR: Manubrial Notch 3" below upper border of film holder

Film Rundown: 10 x 12, L W, B CR: V P Cone: FFC

Alignment: Part Centered, Coronal Plane 20° to 30° obliqued

Breathing Technique: Normal Breathing FFD: 40"

Demonstrates: Entire Sternum and regional soft tissues

Notes: 1. Normal Breathing to blur vascular markings

2. 3 to 5 second exposure time

3. The degree of obliquity will depend on the patients size. A thick person will require less obliquity than a slender person.

4. Patient Dress: Clothing from waist up removed and dressed in a gown.

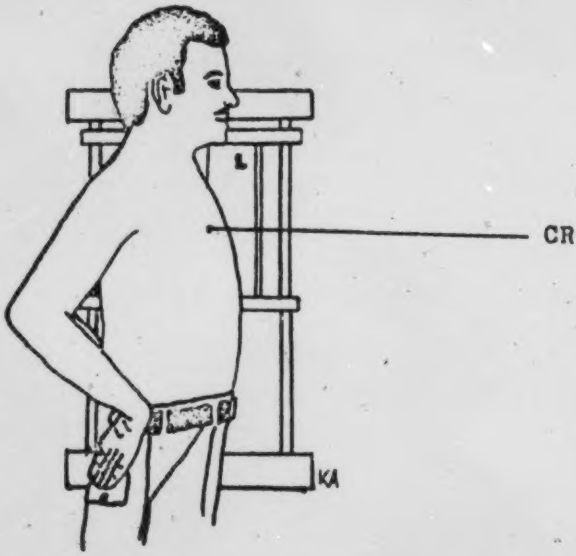
5. ID: Either lateral border.

1110

TM 8-280 pp. 10-61 Figure 10-55

Sternum

Routine: RAO and Lateral



Sternum Position Lateral

PFR: Manubrial notch 3" below upper film border

Film Rundown: 10 x 12, L W, B CR: H P Cone: FFC

Alignment: Median Plane parallel to film with Sternum over the center of film holder.

Breathing Technique: Suspended Inspiration FFD: 40"

Demonstrates: Entire Sternum and regional soft tissues

Notes: 1. Place patients hands, palm out, on back of hips and move shoulders backward.

2. Patient Dress: Clothing from waist up removed and dressed in a gown.

3. ID: Lateral border, anterior to part.

TM 8-280 pp. 10-62 Figure 10-56

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*LP 38-520-062
076

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

Positioning of the Clavicular Joints (1 hour)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES:

TM 8-280, pp 10-29 and 10-63.
Merrill, Vinita. Atlas of Roentgenographic Positions. 3d ed. Vol. I. St. Louis, Missouri: C.V. Mosby Company, 1967, pp 136-137, 160-161.

STUDY ASSIGNMENT: After class study GR 38-520-027-1B and TM 8-280, pp 10-29 and 10-63.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 and GR 38-520-027-1B.

TOOLS, EQUIPMENT, AND MATERIALS: GR 38-520-027-1B issued at beginning of seventh week.

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Radiographs of the Clavicular joints, illuminator, pointer; chalkboard, chalk and eraser; PA system with lapel mike (see Annexes A thru C)

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

I. INTRODUCTION (5 min)

A. Opening Statement: The examinations of the clavicular joints are most often done following an automobile accident or a contact sport. These examinations are not frequently requested; therefore, some specialists have difficulty in obtaining good diagnostic radiographs. As future x-ray specialists, you must know all the procedures necessary to produce diagnostic radiographs of the clavicular joints.

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*This lesson plan supersedes LP 38-520-062, 064.

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B. Objectives

1. Identify by name the position and anatomical structures demonstrated of the routine acromioclavicular joints and the sternoclavicular joints.

2. State the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization, film identification and captioning necessary to demonstrate the position(s) of the routine acromioclavicular joints and sternoclavicular joints.

3. Given a request slip and a simulated patient in the x-ray laboratory, select the proper technical factors, accessory equipment, and the correct positioning data which would produce a technically acceptable radiograph(s) of the routine acromioclavicular joints and sternoclavicular joints.

C. Class Procedure and Lesson Tie-in

1. Students will gather around the x-ray table during the demonstration.

2. Students will be demonstrating these positions in their laboratory practical exercise on crucial objectives.

II. DEMONSTRATION (35 min)

A. Anatomical Structures Demonstrated -- sternoclavicular articulations and acromioclavicular joints.

NOTE: Place radiograph on viewbox and point out the following anatomical structures:

1. Clavicle

2. Sternoclavicular articulation (joint)

3. Acromioclavicular articulation

4. Manubrial notch

5. Scapula

6. Spine (Dorsal)

1112

B. Positions

NOTE: Refer to Annexes A thru C for explanation of positions and have students fill in their GR's.

1. Acromioclavicular Joints (AC Joints) with weights (WW) and without weights (WOW).

QUESTION: What are the routine positions for the acromioclavicular joints?

ANSWER: AP with weights and AP without weights.

NOTE: Explain the purpose of demonstrating both acromioclavicular joints.

2. AC Joints WW and WOW using 8 x 10.

3. Sternoclavicular Joints (Bi-lateral)(RAO and LAO)

NOTE: Emphasize that the patient position is essentially the same as for the RAO sternum, however the median plane is obliqued 15 degrees; additionally both sternoclavicular joints may be demonstrated on a single film with the patient in the true PA position, utilizing a perpendicular central ray, and shortening the FFD to obliterate the spine.

QUESTION: With the patient in the right anterior oblique position, which articulation is being demonstrated?

ANSWER: The left side.

NOTE: Emphasize that the side up is demonstrated.

C. Demonstrate positions using information in Annexes A thru C.

NOTE: Positions will be demonstrated by instructor using a student from the class as a patient and refer students to the order of procedure.

D. Questions From Students

NOTE: Make study assignment: After class study 8-280, pp 10-29 and 10-63, and GR 38-520-027-1B.

III. SUMMARY (5 min)

A. Review of Main Points

1. Anatomical Structures

2. Positions

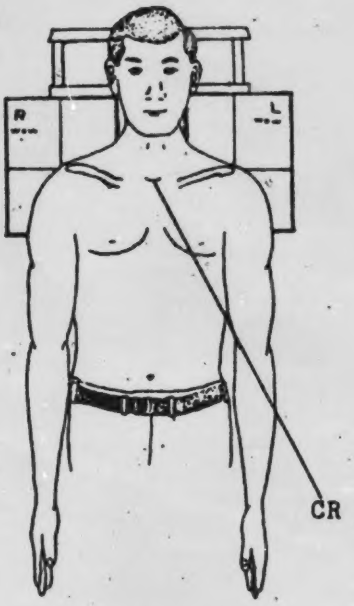
3. Demonstration

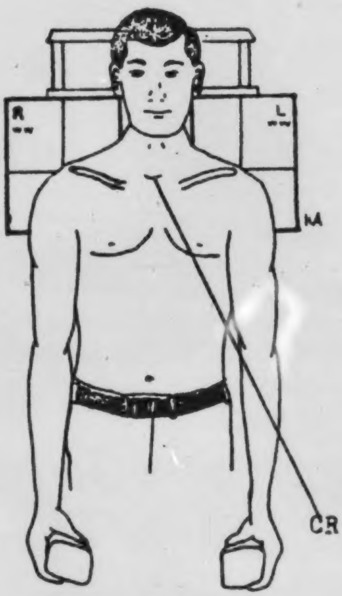
B. Closing Statement: By placing the information given you here in class into the correct order of procedure in positioning, you will be led in only one direction and that direction will be to a diagnostic radiograph of the clavicular joints.

ANNEX A
INSTRUCTIONAL AIDS

Acromioclavicular Joints

Routine: AP with and without weights





Position Without Weights (WOW)   Position With Weights (WW)

PFR: Acromion Process to center of 8 x 10   ID: R and L marker on each film

Film Rundown: 8 x 10, L W, NB   CR: Horizontal Perpendicular to jugular notc

Alignment: Median Plane perpendicular   FFD: 72 "

Breathing Technique: Suspended Respiration

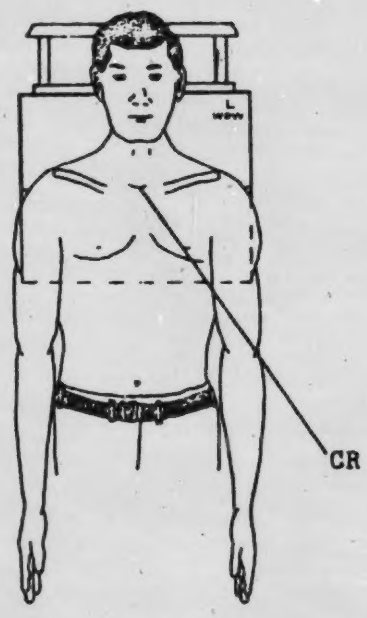
Demonstrates: Acromioclavicular joints

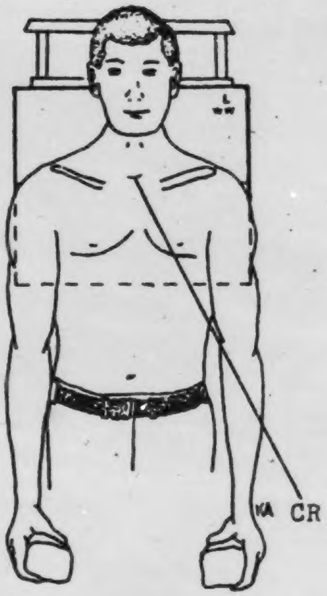
Notes: 1. Separate 8x10's are used to accommodate broad patients where a 14x17 would be too small. 2. The same considerations are used as if using a 14x17 for the procedure. 3. The CR is centered to the jugular notch and both 8x10's exposed simultaneously. 4. ID must include WW or WOW appropriately. 5. Patient standing with equal weight on both feet and holding equal weights in both hands (usually 5 pounds)

TM 8-280 pp. 10-29 Fig. 10-24

Acromioclavicular Joints

Routine: AP with and without weights





Position Without Weights (WOW) Position With Weights (WW)

PFR: Jugular notch to center of film holder ID: Above shoulder both views

Film Rundown: 14 x 17, C W, NB CR: H P Cone: FFC

Alignment: Median Plane perpendicular to center of film

Breathing Technique: Suspended Respiration FFD: 72 "

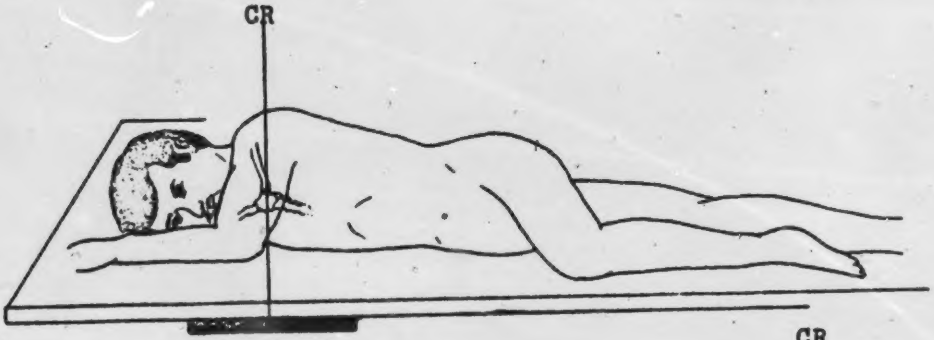
Demonstrates: Acromioclavicular Joints

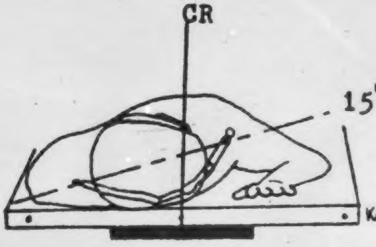
Notes: 1. FFC 72" ; two views; with and without weights to demonstrate acromioclavicular joint separation. 2. ID must include WW (with weights) or WOW (without weights). 3. Patient standing with equal weight on both feet, and holding equal weights in both hands; (usually 5 pounds)

TM 8-280 pp. 10-29 Figure 10-24

Sternoclavicular Joints

Routine: Bilateral Sternoclavicular Joints





Sternoclavicular joints Position RAO, LAO Oblique

PFR: Juglar notch to center of film holder. ID: Correct letter marker in conefield

Film Rundown: 8 x 10, L W, B CR: V P Cone: 6 "

Alignment: Coronal Plane rotated 15° oblique, affected side up

Breathing Technique: Suspended Expdiration FFD: 40 "

Demonstrates: Sternoclavicular Joints side up

Notes: Sternoclavicular joint may be located 1/2 " lateral to the jugular notch

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ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

Film Discussion: Trunk (2 hours)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES:

TM 8-280, pp 10-29, 10-52 thru 10-70, 10-72 thru 10-80.
Merrill, Vinita. Atlas of Roentgenographic Positions. 3d ed. Vol. I, III. St. Louis, Missouri: C.V. Mosby Company, 1967, pp 152-172, 210-215, 220-226, 230-234, 240-252, 258, 259, 546-553, 559-567, 586-588.

STUDY ASSIGNMENT: After class study GR 38-520-027-1B and review seventh week film packet.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 and GR 38-520-027-1B.

TOOLS, EQUIPMENT, AND MATERIALS: GR 38-520-027-1B issued at beginning of seventh week.

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: PA system with lapel mike; bank of viewboxes, pointer and radiographs of the trunk

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

FIRST HOUR

I. INTRODUCTION (2 min)

A. Opening Statement: A part of your job as an X-Ray Specialist will be to examine the radiographs that you have taken and determine if they are acceptable by clinic standards. The fact that we do not take live exposures at the school makes it necessary that we conduct these film discussions periodically during the course. For the past several days, you have been positioning the trunk. During this block of instruction, you will see both acceptable routines and examples of some common errors found in positioning the trunk.

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*This lesson plan supersedes LP 38-520-057, 094.

1118

B. Objectives

1. List the routine and additional positions of the trunk and identify these on radiographs.

2. Given a radiograph of a trunk position:

   a. State the pertinent information necessary to produce that position.

   b. Identify and discuss any error(s) demonstrated on the radiograph.

   c. Identify anatomical structures demonstrated.

C. Class Procedure and Lesson Tie-in

1. This class was preceded by the following related blocks of instruction: Positioning of the Trunk: Cervical Spine, additional views of C-spine, Dorsal spine, Lumbar spine, L-S articulation and Oblique SI, dorsal/lumbar spine.

2. This class will be conducted by showing radiographs and discussing requirements for each position. Emphasis will be placed on areas as indicated by questions from the class.

II. DEMONSTRATION (38 min)

A. The Normal Radiograph

NOTE: Show one radiograph of each procedure progressing from cervical spine through oblique SI, Dor/Lum spine. Review each, requiring students to supply the following information:

1. Name of position

2. Part-to-film holder reference

3. Film rundown

4. Central ray

5. Alignment

6. Anatomy demonstrated

1120

7. Special considerations

B. Common Errors

NOTE: Show one radiograph of each procedure progressing from cervical spine through OBL, SI, Dor/Lum Spine. Choose radiographs that demonstrate probable incorrect procedures for each position so that several factors will be discussed.

1. Film handling
2. Positioning
3. Central Ray
4. Secondary factors of exposure

C. Questions From Students

III. SUMMARY (5 min)

A. Review of Main Points

1. The normal radiograph
2. Common errors

B. Closing Statement: During this hour, you have seen examples of both acceptable and unacceptable radiographs of the trunk, up to and including the OBL, SI, Dor/Lum Spine. We will complete our film disucssion on the trunk following your classes and practical exercises on the chest, ribs, abdomen, sternum and clavicular joints.

SECOND HOUR

I. INTRODUCTION

A. Same as "FIRST HOUR"

B. Same as "FIRST HOUR"

C. Class Procedure and Lesson Tie-in

1. This class was preceded by the following related blocks of instruction: Positioning of the Trunk: Chest, Ribs, Abdomen, Sternum and Clavicular Joints.
2. This class will be conducted by showing radiographs and discussing requirements for each position. Emphasis will be placed on areas as indicated by questions from the class.

II. **EXPLANATION/DEMONSTRATION** (40 min)

A. The Normal Radiograph

NOTE: Show one radiograph of each procedure progressing from chest through clavicular joints. Review each, requiring students to supply the following information.

1. Name of position
2. Part-to-film holder reference
3. Film rundown
4. Central ray
5. Alignments
6. Anatomy demonstrated
7. Special considerations

B. Common Errors

NOTE: Show one radiograph of each procedure progressing from chest through clavicular joints. Choose radiographs that demonstrate probable incorrect procedures for each position so that several factors will be discussed.

1. Film handling
2. Positioning
3. Central ray
4. Secondary factors of exposure

C. Questions From Students

III. SUMMARY (5 min)

A. Review of Main Points

1. The normal radiograph
2. Common errors

B. Closing statement: When a repeat study is necessary, analyze the original radiograph and take the necessary measures to correct the errors.

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076

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

Positioning of the Skull: Cranium (2 hours)

COURSES PRESENTED TO: Radiographic Procedures (Basic) 313-91P20

PLACE: Classroom

REFERENCES:

TM 8-280, pp 10-82 thru 10-85.
Merrill, Vinita. Atlas of Roentgenographic Positions. 3d ed., Vol. II. St. Louis: C.V. Mosby Company, 1967, pp 312-313, 332-342.

STUDY ASSIGNMENT: After class study, GR 38-520-027-1C and TM 8-280, pp 10-82 thru 10-85.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 and GR 38-520-027-1C.

TOOLS, EQUIPMENT, AND MATERIALS: GR 38-520-027-1C issued at beginning of ninth week.

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Chalkboard, chalk, and eraser; pointer, radiographs of the skull and x-ray illuminators. PA system with lapel mike (see Annex A thru F)

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

FIRST HOUR

I. INTRODUCTION (2 min)

A. Opening Statement: In the days of King Arthur, knights and squires donned suits of armor to protect their bodies from injury on the battlefield. Today, even though the human body is seldom subject to this same type of physical violence, we still need some type of "armor" to protect our vital internal organs from damage. This is especially true in the area of the head, where the delicate brain, eyes, and auditory apparatus are afforded this "armor-like" protection by the skull.

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*This lesson plan supersedes LP 38-520-058, 094.

We all know, however, that unlike steel armor, the skull can be injured, and that a skull injury is extremely serious because of the delicate organs protected by it.

B. Objectives

1. Identify by name the position and anatomical structures demonstrated of the routine and additional views of the skull.

2. State the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization, film identification and captioning necessary to demonstrate the position(s) of the routine and additional view of the skull.

3. Given a request slip and a simulated patient in the x-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiograph(s) of the routine and additional views of the skull.

C. Class Procedure and Lesson Tie-in

1. Students will gather around the x-ray table during the demonstration.

2. Students will demonstrate these positions in their laboratory practical exercise on crucial objectives.

II. DEMONSTRATION (75 min)

A. Anatomical Structures Demonstrated — Skull

NOTE: Use a dry skull and radiographs of the skull, point out the bones of the cranium.

1. Frontal (1)
2. Parietal (2)
3. Temporal (2)
4. Occipital (1)
5. Sphenoid (1)
6. Ethmoid (1)

NOTE: Review and/or discuss all terms found in Annex A.

QUESTION: What two points are used to determine the orbitomeatal line?

ANSWER: External canthus of the eye and external auditory meatus.

QUESTION: Where is the glabella?

ANSWER: It is the anterior protuberance of the frontal bone.

NOTE: Instructor emphasize the atypical Craniums, the Brachycephalic and Dolichocephalic found in Annex B.

NOTE: Instructor emphasize the typical; Mesocephalic Cranium will be the basis for skull positions.

B. Positions

NOTE: Refer to Annex C thru F for explanation of positions and have the students fill in their GR's.

1. Posterior-anterior (routine)

NOTE: Instructor emphasize AP skull done only when PA cannot be obtained.

2. Bi-lateral (routine)

3. Chamberlain-Towne (routine)

NOTE: Midpoint of EOP--glabella line is placed over midline of table on lateral skull positions.

4. Bowen-Hirtz (Basal View) - Additional View

5. Variations

   a. Modified PA skull-15 degree Caudad CR.

NOTE: Explain that 15 degree caudad may be used to bring the petrous ridges to the lower one-third of the orbits, allowing visualization and demonstration of the ridges within the orbits.

   b. Modified PA skull-23 degree Caudad CR.

NOTE: Explain that with this combination of two-way head alignment and angle and direction of the central ray, the petrous ridges are projected completely out of the orbits.

NOTE: On variation views of the skull, all positioning requirements remain the same except the angle and direction of the CR.

SECOND HOUR

NOTE: Discuss and emphasize the importance of two-way head alignments.

NOTE: Instructor emphasize the importance of removing necklaces, earrings, dentures, and hair arrangement accessories when performing radiographs of the skull.

NOTE: Bowen-Hirtz may be performed sitting erect (preferred) or may be done supine with buttress placed under shoulders.

C. Demonstrate positions using information in Annexes C thru F.

NOTE: Positions will be demonstrated by instructor using a student from the class as a patient and refer students to the order of procedure.

QUESTION: What area of the skull is demonstrated in the Bowen-Hirtz view?

ANSWER: Basilar.

D. Questions From Students

NOTE: Make study assignment: After class study TM 8-280, pp 10-82 thru 10-85 and GR 38-520-027-1C.

III. SUMMARY (13 min)

A. Review of Main Points

1. Anatomical Structures

2. Positions

3. Demonstrations

B. Closing Statement: Positioning the skull calls for much more precision and accuracy. As an integral member of the health care team, demonstrate your true professional qualities by striving for your perfection and precision. Then ask yourself; "Have I really arrived?"

ANNEX A
INSTRUCTIONAL AID

Glossary of Locational Anatomy of the Skull

1. NASOLABIAL JUNCTION: Soft tissue junction of the nose and upper lip.

2. ANTERIOR NASAL SPINE: The bony spine that is situated at the nasolabial junction. This spine makes the midline junction of the two maxillae bones.

3. ACANTHION: The anterior tip of the anterior nasal spine.

4. EXTERNAL AUDITORY MEATI (EAMS): External opening or hole in the ears leading to the eardrum.

5. ACANTHIO-MEATAL LINE (AML): A line from the nasolabial junction to the EAM. (External Acoustic Meatus)

6. APEX (ex or ices): The point of a pyramidal structure, e.g., apex of the skull, which is the top of the head at the junction of the coronal and midsagittal sutures.

7. BILATERAL: On both sides, pertaining to the right and the left sides.

8. EXTERNAL OCCIPITAL PROTUBERANCE (EOP): The protuberance at the base of the skull on the external surface of the occipital bone. Often referred to as the inion.

9. EXTERNAL CANTHUS OF EYE: Outer (lateral) angle formed by the junction of the eyelids. May be called Temporal Canthus.

10. GLABELLA: Anterior protuberance of the frontal bone (between the eyebrows).

11. INFRAORBITOMEATAL LINE (IOML): A line from the infraorbital ridge or margin to the EAM. Also known as Reid's Base Line and the Line of Frankfurt.

12. INTERPUPILLARY LINE: Line through (connecting) pupils of both eyes when the eyes are in a neutral position, looking straight ahead.

13. LAMBDA (of the skull): At the base of skull; the junction of the midsagittal and lamboidal sutures.

14. NASION: Junction of frontal and nasal bones.

1126

LP 38-520-058
076

15. OCCLUSAL: The masticating or grinding surfaces of the molars and premolars.

16. OCCLUSAL FILM: Type of film which is usally placed between the occlusal surfaces of the teeth.

17. OCCIPUT: Back of the head.

18. ORBITAL LINE: Line through (connecting) the external canthi of the eyes.

19. ORBITOMEATAL LINE (OML): A line from the external canthus of the eye to the EAM (often referred to as the radiographic base line and the international base line).

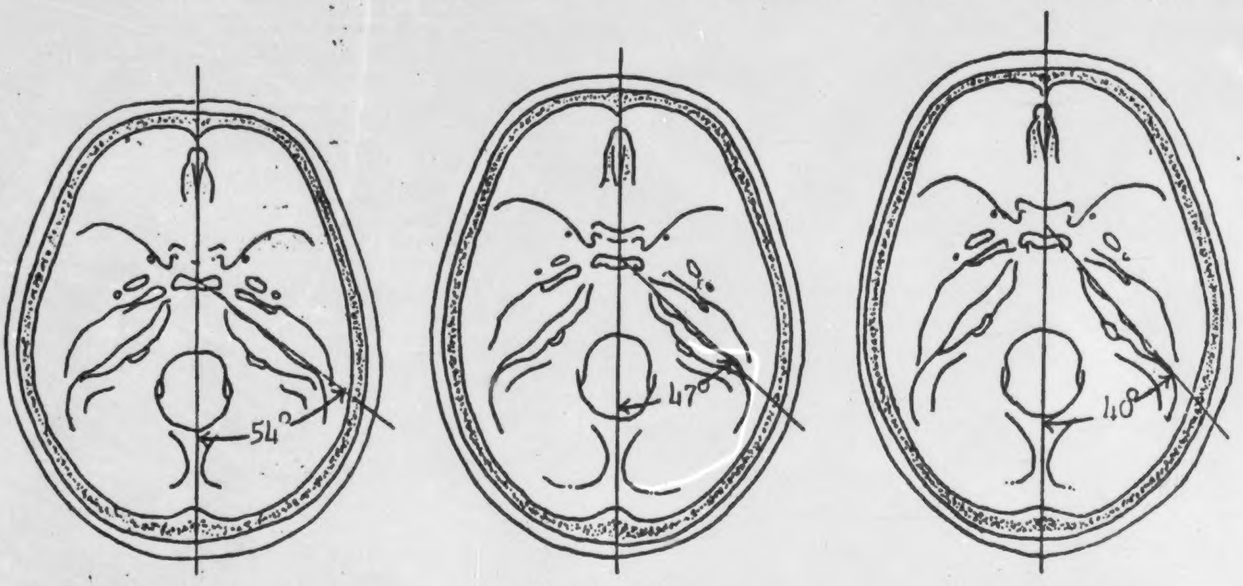
20. CRANIAL THICKNESS: The cranial bones are flat bones composed of a dense outer layer of bone known as the outer table, a less dense middle zone known as diploe and another dense internal layer known as the inner table.

Reference: An Atlas of Normal Radiographic Anatomy by Isadone Meschan, M.A., M.D., 2d ed., W.B. Saunders and Company, Philadelphia and London, 1960.

1128

ANNEX B
INSTRUCTIONAL AID

Atypical craniums will, depending upon their shape, require more or less rotation of the head or an increase or decrease in the angulation of the central ray.



BRACHYCEPHALIC
(ATYPICAL)

MESOCEPHALIC
(TYPICAL)

DOLICHOCEPHALIC
(ATYPICAL)

In the brachycephalic head, which is short from front to back, broad from side to side, and shallow from vertex to base, the internal structures are higher with reference to the base line and their long axis are more frontal in position; they form a wider angle with the median sagittal plane.

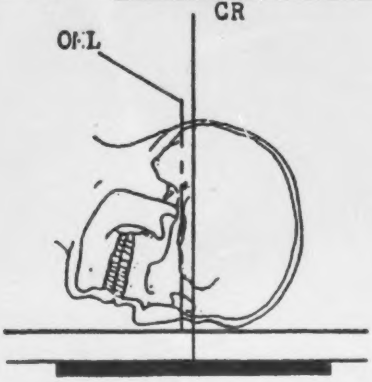
In the dolichocephalic head, which is long from front to back, narrow from side to side, and deep from vertex to base, the internal structures are lower with reference to the base line and their long axis are less frontal in position; they form a narrower angle with the median sagittal plane.

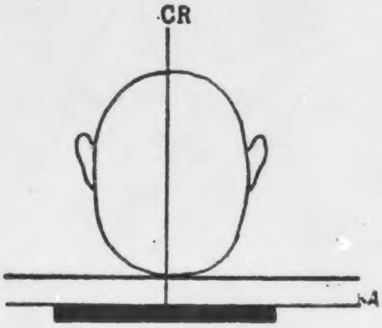
INSTRUCTIONAL AIDS

Skull

Routine: Posterior-Anterior, Bi-lateral, and Chamberlain-Towne

Additional: Bowen-Hirtz





Skull Position Posterior-Anterior

PFR: Glabella to center of film holder

Film Rundown: 10 x 12, LW, B ID: Either lateral border

CR VP Cone: FFC

TWHA: Median Plane perpendicular, and Orbital Meatal Line perpendicular to film.

Breathing Technique: Suspended Respiration FFD: 40"

Demonstrates: Frontal bone, and a general survey of cranium

Notes: 1. Before positioning patient, make sure eye glasses, dentures, hairpins, and earrings have been removed. (for all positions of the skull)

2. On this PA view, the Petrous Ridges completely fill the orbits

3. To free the orbits of the Petrous Ridges angle the CR 23° caudad

4. To place the Petrous Ridges in the lower 1/3 of the orbits, angle the CR 15° caudad

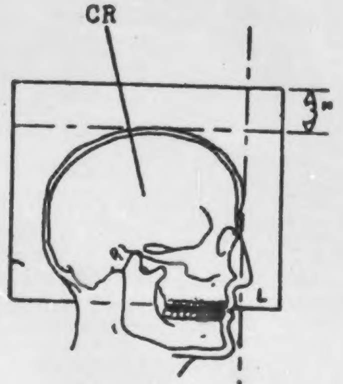
5. Ensure that the patient is in the nose forehead position

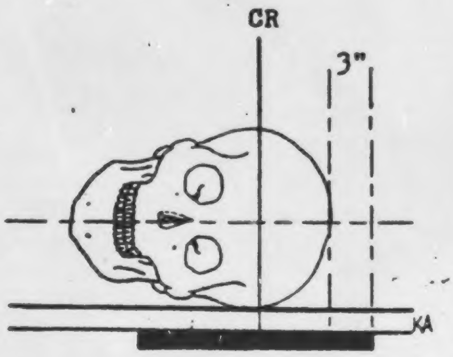
1129

Skull

Routine: Posterior-Anterior, Bi-lateral, and Chamberlain-Towne

Additional: Bowen Hirtz





Skull Position Lateral

PFR: Vertex of skull 3" below upper border of film holder

Film Rundown: 10 x 12, CW, B ID: Lateral border anterior to part

CR: V P Cone: FFC

TWHA: Median plane parallel to film, and Facial plane parallel to lateral border of film holder.

Breathing Technique: Suspended Respiration FFD: 40"

Demonstrates: Superimposed halves of the cranium, the sella tursica, the temporal and parietal bones

Notes: 1. Side closest to film is best demonstrated

2. To center the skull, mid-point between EOP and the glabella line over the centerline of the table

3. Before positioning the patient make sure all dentures, eyeglasses etc have been removed (for all positions of the skull)

4. Fist may be used for support beneath the chin, to aid in immobilization

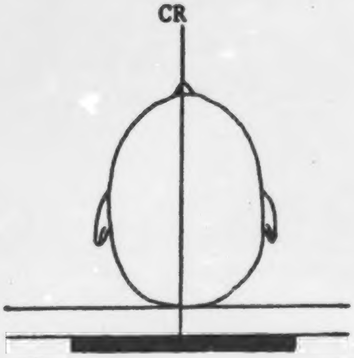
TM 8-280 pp. 10-83 Figure 10-77

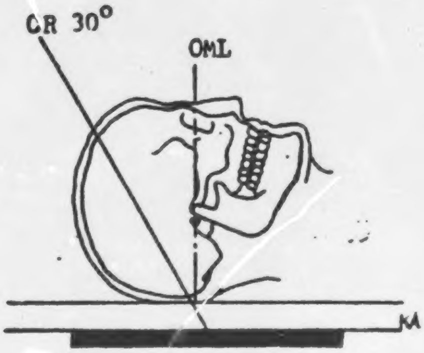
076 1130

INSTRUCTIONAL AIDS
Skull

Routine: Posterior-Anterior, Bi-lateral, and Chamberlain-Towne

Additional: Bowen-Hirtz





Skull Position Chamberlain-Towne

PFR: Vertex of skull even with upper border of film holder

Film Rundown: 10 x 12, L W, B ID: Either lateral border

CR: 30° Caudad Cone: FFC

Breathing Technique: Suspended Respiration FFD: 40 "

Demonstrates: Occipital bone, foramen magnum, Petrous ridges, and Mastoid air cells

TWHA: Median plane perpendicular, and Orbital meatal line perpendicular to film.

Notes: 1. Before positioning patient remove all dentures, hairpins etc. have been removed for all positions of the skull.

2. Do upright with vertical bucky when you cannot get Orbital Meatal Line perpendicular with patient supine.

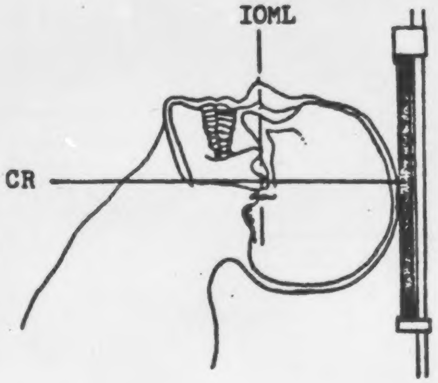
3. Modified Chamberlain-Towne: To demonstrate both condyles of the mandible direct the CR to midpoint of a line connecting the External Auditory Meatus' to center of film holder.

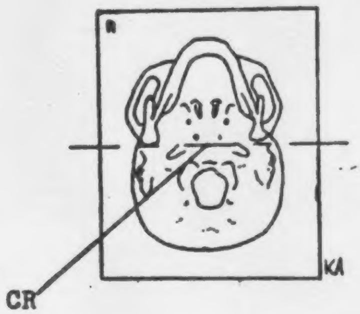
TM 8-280 pp. 10-84 Figure 10-78

Skull INSTRUCTIONAL AIDS U/U

Routine: Posterior-Anterior, Bi-lateral, and Chamberlain-Towne

Additional: Bowen-Hirtz





Skull Position Bowen-Hirtz

PFR: Midpoint of angles of mandible to center of film holder

Film Rundown: 10 x 12, L W, B ID: Either lateral border

CR: H P Cone FFC

Breathing Technique: Suspended Respiration FFD: 40"

Demonstrates: Basilar portion of skull, foramen magnum, sphenoid and posterior ethmoid sinuses

TWHA: Median plane perpendicular, and Infraorbital meatal line parallel to film

Notes: 1. Patient may be positioned erect (sitting). Patient may also be positioned supine with shoulders buttressed.

2. Before positioning patient, make sure eyeglasses, dentures, etc have been removed. (for all positions of the skull)

TM 8-280 pp. 10-85 Figure 10-79

SFC JIMMIE BINKLEY
*LP 38-520-059
076

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

Positioning of the Skull: Sinus (2 hours)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES:

TM 8-280, pp 10-86 through 10-88
Merrill, Vinita. *Atlas of Roentgenographic Positions*. 3d ed., Vol II St. Louis, Missouri: C.V. Mosby Company, 1967, pp 420-421, 424-431, 434-435

STUDY ASSIGNMENT: After class study GR 38-520-027-1C and TM 8-280, pp 10-86 through 10-88

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 and GR 38-520-027-1C

TOOLS, EQUIPMENT, AND MATERIALS: GR 38-520-027-1C issued at beginning of ninth week.

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Radiographs of the sinuses, pointer, and X-ray illuminator; chalkboard, chalk, and eraser. PA system with lapel mike; illustrations (see Annexes A through C)

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

FIRST HOUR

I. INTRODUCTION (5 min)

A. Opening Statement: Sinus trouble is prevalent in the Army because we are frequently subject to transfer from one geographical climate area to another. During the process of adjustment many personnel encounter sinus discomfort, especially if the transfer was from a rather dry to a more humid area. Often, such relocations result in sinusitis or other inflammations of the sinus region. While working in the X-ray clinic you will frequently be taking radiographs of the sinus area.

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*This lesson plan supersedes LP 38-520-059, 094

B. Objectives

1. Identify by name the position and anatomical structures demonstrated of the routine sinus.

2. State the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization, film identification and captioning necessary to demonstrate the position(s) of the routine sinus.

3. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiograph(s) of the routine sinus.

C. Class Procedure and Lesson Tie-in

1. Students will gather around the X-ray table during the demonstration.

2. Students will demonstrate these positions in their laboratory practical exercise on crucial objectives.

II. DEMONSTRATION (80 min)

A. Anatomical Structures Demonstrated - Sinus

NOTE: Place radiographs on viewbox and point out the following anatomical structures.

1. Skull
    a. Frontal bone
    b. Maxillary bone
    c. Ethmoid bone
    d. Sphenoid bone
2. Paranasal sinuses
    a. Frontal and ethmoid sinuses
        (1) Demonstrated by Caldwell's view
        (2) Location--anterior portion of frontal bone and ethmoid bone

NOTE: Petrous ridges at the lower third of the orbits.

b. Maxillary sinuses

(1) Demonstrated by Waters' view

(2) Location--superior portion of the maxillary bone

NOTE: The Maxillary sinuses are the only sinuses which have their drainage point near the roof instead of at a low point.

NOTE: Petrous ridges are seen below the maxillary sinuses.

c. All sinuses

(1) Demonstrated by a lateral view

(2) Location--frontal bone, ethmoid bone, sphenoid bone, and maxillary bone

B. Positions

NOTE: Refer to Annexes A through C for explanation of positions and have the students fill in their GR's.

1. Caldwell's (routine)
2. Waters' (routine)
3. Lateral (routine)

QUESTION: Where will the petrous ridges fall within the orbits on Caldwell's projection?

ANSWER: Lower third.

QUESTION: Which sinuses are demonstrated with the Waters' position?

ANSWER: Maxillary.

QUESTION: Name the part-to-film reference for the Waters' sinus position.

ANSWER: Acanthion to center.

QUESTION: How many sinuses are demonstrated with the Waters' sinus position?

ANSWER: Three.

NOTE: Sphenoidal sinusitis is the most serious because of its proximity to the Pituitary Gland.

C. Demonstrate positions using information in Annexes A through C.

NOTE: Positions will be demonstrated by the instructor using a student from the class as a patient and refer students to the order of procedure.

D. Questions from Students.

NOTE: Make Study Assignment: After class study TM 8-280, pp 10-86 through 10-88 and GR 38-520-027-1C.

III. SUMMARY (5 min)

A. Review of Main Points

1. Anatomical Structures

2. Positions

3. Demonstration

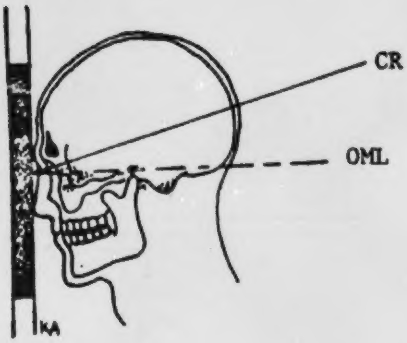
B. Closing Statement: Because of their close proximity to each other, as well as adjacent structures, the Sinus present a particular and rather unique challenge to the technologist. There is little latitude for error. Correct handling, proper alignment and CR placement will provide the desired results for the patients' diagnoses.

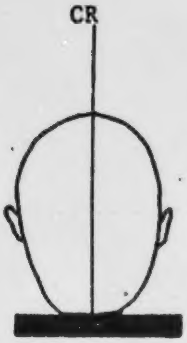
076 1136

INSTRUCTIONAL AIDS

Sinus

Routine: Waters, Caldwell, and Lateral





Sinus Position Caldwell

PFR: Nasion to center of film holder

Film Rundown: 8 x 10, L W, B ID: Either lateral border within cone field

CR: 15° Caudad Cone: 6 "

Breathing Technique: Suspended Respiration FFD: 40 "

Demonstrates: Primarily: frontal and anterior ethmoid sinuses
Secondarily: orbits and petrous ridges

TWHA: Median plane perpendicular, and Orbital meatal line perpendicular to film.

Notes: 1. Patient erect to demonstrate fluid levels

2. All artifacts removed to include dentures.

3. Posterior ethmoidal cells are demonstrated best by utilizing a H P CR directed to center of film holder

1138

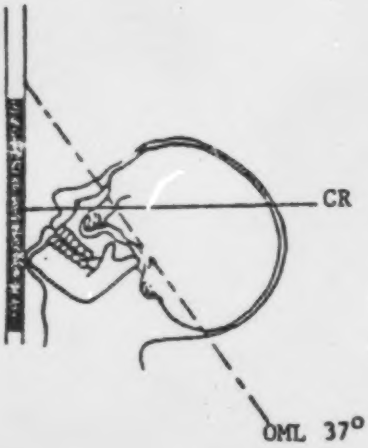
TM 8-280 pp. 10-86 Figure A-1 10-80

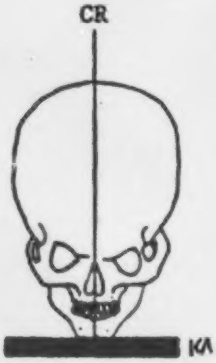
LP 38-520-059
076 1137

ANNEX B
INSTRUCTIONAL AIDS

Sinus

Routine: Waters, Caldwell, and Lateral





Sinus Position Waters

PFR: Acanthion to center of film holder

Film Rundown: 8 x 10, L W, B ID: Either lateral border within cone field

CR: H P Cone: 6"

Breathing Technique: Suspended Respiration FFD: 40"

Demonstrates: Primarily: maxillary sinus
Secondarily: frontal and ethmoid sinuses, orbits and zygoma

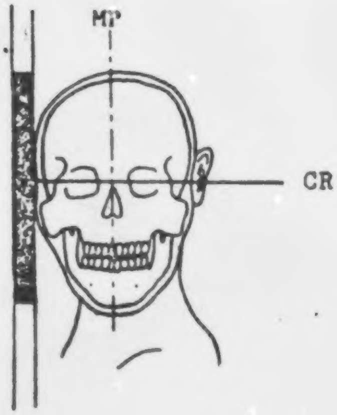
TWHA: Median plane perpendicular, and Orbital meatal line forms an angle of 37° with the film

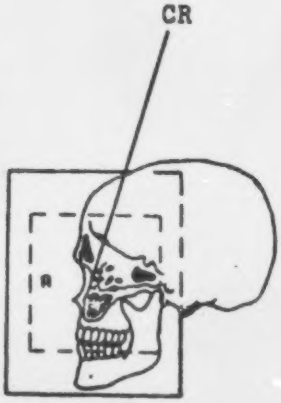
Notes: 1. All sinuses are done erect to show fluid level

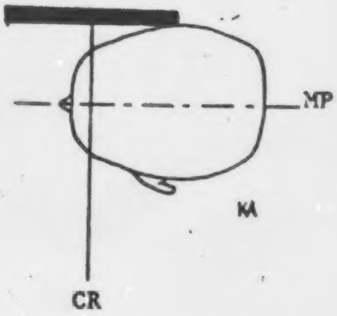
2. All artifacts removed to include dentures.

TM 8-280 pp. 10-87 Figure 10-81

Routine: Waters, Caldwell, and Lateral







Sinus Position **Lateral**

PFR: External canthus of the eye to center of film holder

Film Rundown: 8 x 10, L W, B ID: Correct letter marker in condf

CR: H P Cone: 6 "

Breathing Technique: Suspended Respiration FFD: 40 "

Demonstrates: Frontal, ethmoid, sphenoid, and maxillary sinuses

TWHA: Median plane parallel to film, and Facial plane parallel to lateral border of film holder

Notes: 1. All artifacts removed to include dentures

2. Lateral view demonstrates all parnasal sinuses

1140

TM 8-280 pp. 10-88 Figure 10-82

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ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

*LP 38-520-067
076

Positioning of the Skull: Mandible (1 hour)

COURSES PRESENTED TO: Radiographic Procedures (Basic), 313-91P20

PLACE: Classroom

REFERENCES:

TM 8-280, pp 10-99 through 10-100.
Merrill, Vinita. Atlas of Roentgenographic Positioning. 3d ed, Vol II St. Louis, Missouri: C. V. Mosby Company, 1967, pp 326, 466-472.

STUDY ASSIGNMENT: After class study TM 8-280, pp 10-99 through 10-100 and GR 38-520-027-1C.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 and GR 38-520-027-1C

TOOLS, EQUIPMENT, AND MATERIAL: GR 38-520-027-1C issued at beginning of ninth week.

PERSONNEL: One instructor (MOS 91P4H or 91P2H)

INSTRUCTIONAL AIDS: Radiographs of the mandible; pointer, and X-ray illuminators; chalkboard, chalk, and erasers; PA system with lapel mike. (See Annexes A through B)

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

I. INTRODUCTION (2 min)

A. Opening Statement: The radiographic procedure to be covered during this hour correlates with the first position you were taught--the hand. Because altercations can easily occur between individuals, it is almost certain that one or both of the combatants will be require X-rays; one for his hand and the other for his mandible. It is necessary that we, as X-Ray Specialists, be able to satisfactorily demonstrate either of these procedures with a minimum of difficulty.

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*This lesson plan supersedes LP 38-520-067, 074

B. Objectives

1. Identify by name the position and anatomical structures demonstrated of the routine mandible.

2. State the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization, film identification and captioning necessary to demonstrate the position(s) of the routine mandible.

3. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiograph(s) of the routine mandible.

C. Class Procedure and Lesson Tie-in

1. Students will gather around the X-ray table during demonstration.

2. Students will demonstrate the positions in the laboratory practical exercise on crucial objectives.

II. DEMONSTRATION (38 min)

A. Anatomical Structures Demonstrated - Mandible

NOTE: Place radiographs on view box and point out the following anatomical structures:

1. Ramus
2. Angle of the mandible
3. Body of the mandible
4. Mental protuberance
5. Condyloid process
6. Coronoid process
7. Mandibular notch

B. Positions

NOTE: Refer to Annexes A and B for explanation of positions and have the students fill in their GR's.

1. PA (routine)

2. Lateral (R and L) (routine)

C. Demonstrate Position Using Information in Annexes A and B.

NOTE: Positions will be demonstrated by the instructor using a student from the class as a patient and refer students to the order of procedure.

QUESTION: What anatomical structure(s) of the mandible is demonstrated in the PA projection?

ANSWER: Entire mandible.

NOTE: Cassette is placed on the top of small sandbags.

QUESTION: What is the angle and direction of the central ray for the lateral routine mandible?

ANSWER: Thirty degrees cephalic.

D. Questions from Students

NOTE: Make study assignment: After class study TM 8-280, pp 10-99 through 10-100, and GR 38-520-027-1C.

III. SUMMARY (5 min)

A. Review of Main Points

1. Anatomical Structures

2. Positions

3. Demonstration

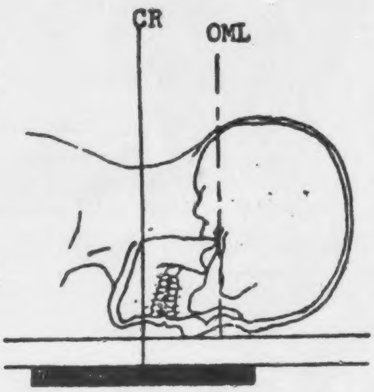
B. Closing Statement: The mandible like all skull positioning requires great precision and a particular expertise when properly performed. An inadequate film utilized by a physician could lead to treatment resulting in a poor cosmetic appearance as well as pain during mastication. Due consideration for these as well as technical factors are of prime importance to the X-ray technologist.

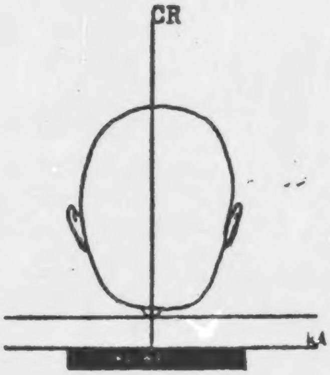
076 1142

INSTRUCTIONAL AIDS

Mandible

Routine: PA and Bi-Lateral





Mandible Position PA

PFR: Midpoint of a line connecting angles of mandible to center of film holder ID: Either lateral border

Film Rundown: 8 x 10, L W, B CR: V P Cone: FFC

TWHA Median plane perpendicular, and Orbital meatal line perpendicular to film.

Breathing Technique: Suspended Respiration FFD: 40 "

Demonstrates: Entire mandible

Notes: 1. Nose forehead position

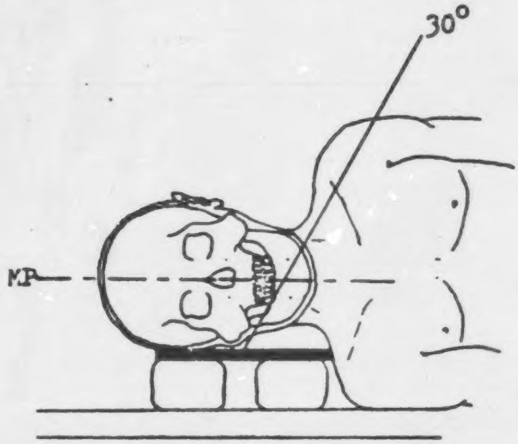
2. Remove all foreign objects from area of mandible, necklaces, dentures etc.

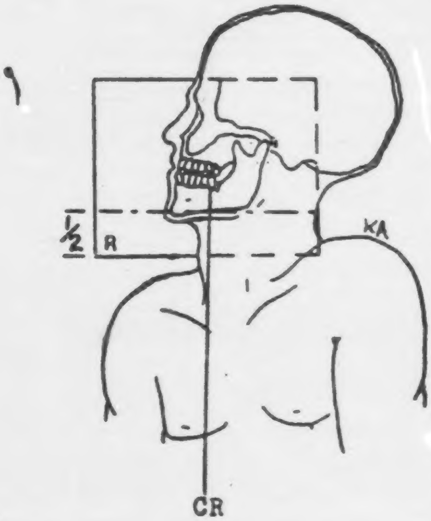
1144

TM 8-280 pp. 10-99 Figure 10-92

Mandible

Routine: PA and Bi-Lateral





Mandible Position Lateral

PFR: Center of body of mandible to center lower half of film holder

Film Rundown: 8 x 10, C W, NB FFD: 40 " ID: Lateral border anterior to part

CR: 30° Cephalic Cone: FFC

Alignment: Median plane parallel to film and inferior margin of body of mandible parallel with lower film border

Breathing Technique: Suspended Respiration

Demonstrates: Ramus and body of mandible, side closest to film

Notes: 1. In the lateral mandible position, the film should be raised approximately 4" to 6"

2. Remove foreign objects from area of mandible: necklaces, dentures etc.

3. Rotate the elevated shoulder rearward, taking care to see that the shoulder is not in the path of the CR

1144

SFC JIMMIE BINKLEY
*LP 38-520-064
076

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

Film Discussion: Cranium-Skull and Supplemental Positions (2 hours)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES:

TM 8-280, pp 10-82 through 10-108.
Merrill, Vinita. Atlas of Roentgenographic Positions. 3d ed, Vol I & II St. Louis, Missouri: C. V. Mosby Company, 1967, pp 58, 104, 105, 132, 133, 312-337, 382, 383, 388, 400-404, 420-428, 434-440, 446, 448, 450, 468, 472 480.

STUDY ASSIGNMENT: After class study GR 38-520-027-1C and review ninth week film packet

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 and GR 38-520-027-1C

TOOLS, EQUIPMENT, AND MATERIALS: GR 38-520-027-1C issued at beginning of ninth week.

PERSONNEL One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: PA system with lapel mike; X-ray illuminators, pointer and radiographs of the skull and supplemental views.

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration (2 hours)

FIRST HOUR

I. INTRODUCTION (2 min)

A. Opening Statement: A part of your job as an X-Ray Specialist will be to examine the radiographs that you have taken and determine if they are acceptable by clinic standards. The fact that we do not take live exposures at the school makes it necessary that we conduct these film discussions periodically during the course. For the past several days, you have been positioning the skull and supplemental views. During this block of instruction, you will see both acceptable routines and examples of some common errors found in their positioning.

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*This lesson plan supersedes LP 38-520-064, 094

B. Objectives

1. List the routine and supplemental positions of the skull and identify these on radiographs

2. Given a radiograph of the routine skull and supplemental positions:

    a. State the pertinent information necessary to produce that position.

    b. Identify and discuss any error(s) demonstrated on the radiograph.

    c. Identify anatomical structures demonstrated.

C. Class Procedure and Lesson Tie-in

1. This class was preceded by the following related blocks of instruction: Positioning of the Cranium: Skull, Sinus, and the Mandible.

2. This class will be conducted by showing radiographs and discussing requirements for each position. Emphasis will be placed on areas as indicated by questions from the class.

II. DEMONSTRATION (38 min)

A. The Normal Radiograph

NOTE: Show one radiograph of each procedure progressing from skull through mandible. Review each, requiring students to supply the following information.

1. Name of position
2. Part-to-film holder reference
3. Film Rundown
4. Central ray/CRPR
5. Alignment
6. Anatomy demonstrated
7. Special considerations

QUESTION: What is the two-way head alignment for the PA skull?

ANSWER: Median plane perpendicular and the Orbitalmeatal Line perpendicular.

B. Common Errors

NOTE: Show one radiograph of each procedure progressing from skull through mandible. Choose radiographs that demonstrate probable incorrect procedures for each position so that several factors will be discussed.

1. Film handling
2. Positioning
3. Central ray/CRPR
4. Secondary factors of exposure

QUESTION: The Maxillary sinuses are demonstrated best on what view?

ANSWER: Waters'

C. Compare the following radiographs:

NOTE: Instructor emphasize similarity and essential difference in these views.

1. Posterior-Anterior skull with Anterior-Posterior skull.
2. Posterior-Anterior skull 15° with Caldwell's sinus.

D. Questions from Students

III. SUMMARY (5 min)

A. Review of Main Points

1. The Normal Radiograph
2. Common Errors

B. Closing Statement: During this hour, you have seen examples of both acceptable and unacceptable radiographs of the Cranium, up to and including the Mandible. We will continue our film discussion on the Cranium following your classes and practical exercises on the Mastoid/TMJ, Nose/Facial Bones, Petrous Ridges, Zygomatic Arches and Rhese's Optic Foramen.

SECOND HOUR

I. INTRODUCTION

A. Same as "FIRST HOUR"

1147

B. Same as "FIRST HOUR"

C. Class Procedure and Lesson Tie-in

This class was preceded by the following related blocks of instruction: Positioning of the Cranium: Mastoid/TMJ, Nose/Facial Bones, Petrous Ridges, Zygomatic Arches and Rhese's Optic Foramen.

II. EXPLANATION (40 min)

A. The Normal Radiograph

NOTE: Show one radiograph of each procedure progressing from Mastoid/TMJ through Rhese's Optic Foramen. Review each, requiring students to supply the following information.

1. Name of position
2. Part-to-film holder reference
3. Film rundown
4. Central ray/CRPR
5. Alignments
6. Anatomy demonstrated
7. Special considerations

QUESTION: The angle and direction of the central ray for Law's lateral mastoid is?

ANSWER: 15 degrees caudad.

B. Common Errors

NOTE: Show one radiograph of each procedure, progressing from Mastoid/TMJ through Rhese's Optic Foramen. Choose radiographs that demonstrate probable incorrect procedures for each position so that several factors will be discussed.

1. Film handling
2. Positioning
3. Central ray/CRPR
4. Secondary factors of exposure

QUESTION: The routine positions for Schuller's TMJ's consist of?

ANSWER: Right and left (bi-lateral) open and closed.

C. Compare following radiographs

1. Law's lateral mastoid with Schuller's TMJ.

2. Law's lateral mastoid with Arcelin's and Stenvers petrous ridge.

D. Questions from Students

III. SUMMARY (5 min)

A. Review of Main Points

1. The Normal Radiograph

2. Common Errors

B. Closing Statement: When a repeat study is necessary, analyze the original radiograph and take the necessary measures to correct the errors.

SFC JIMMIE BINKLEY

ACADEMY OF HEALTH SCIENCES, US ARMY *LP 38-520-068
DIVISION OF MEDICINE AND SURGERY 076
X-RAY BRANCH

Positioning of the Skull: Mastoid and Temporomandibular Joint (2 hours)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES:

TM 8-280, pp 10-92 and 10-93
Merrill, Vinita. Atlas of Roentgenographic Positions. 3d ed, Vol II
St Louis: The C. V. Mosby Company, 1967, pp 388-391, 476-483.

STUDY ASSIGNMENT: After class study TM 8-280, pp 10-92 and 10-93, and GR 38-520-027-1C.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 and GR 38-520-027-1C

TOOLS, EQUIPMENT, AND MATERIALS: GR 38-520-027-1C issued at beginning of ninth week.

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Radiographs of the mastoid tips and temporomandibular joints, X-ray illuminator and pointer; chalkboard, chalk, and eraser, PA system with lapel mike. (See Annexes A through C)

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

I. INTRODUCTION (2 min)

A. Opening Statement: Regardless of the efforts employed by man to protect his face in combat or peacetime, there are accidents and diseases involving the temporomandibular articulation and mastoids. You can expect to encounter patients requiring radiographs of these areas. As future X-ray Specialists you must remember that proper patient handling and precise positioning are extremely vital in these procedures.

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*This lesson plan supersedes LP 38-520-068, 094

B. Objectives

1. Identify by name the position and anatomical structures demonstrated of the routine mastoids and temporomandibular joints.

2. State the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization, film identification and captioning necessary to demonstrate the position(s) of the routine mastoids and temporomandibular joints.

3. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning date which would produce a technically acceptable radiograph(s) of the routine mastoids and temporomandibular joints.

C. Class Procedure and Lesson Tie-in

1. Students will gather around the X-ray table during the demonstration.

2. Students will demonstrate the positions in their laboratory practical exercise on crucial objectives.

II. DEMONSTRATION (85 min)

A. Anatomical Structures Demonstrated - Mastoids and Temporomandibular Joints

NOTE: Place radiographs on view box and point out the following anatomical structures.

1. Mastoid air cells

2. External auditory meatus

3. Temporomandibular joints

4. Petrous ridge

5. Mandible

    a. Condyloid process

    b. Coronoid process

    c. Mandibular notch

6. Temporal bone

a. Mandibular fossa (glenoid fossa)

b. External auditory meatus

c. Mastoid process

QUESTION: What external landmark located near the mastoid air cells, is used as reference point for positioning Law's mastoid?

ANSWER: Tragus of the ear.

B. Positions

NOTE: Refer to Annexes A through C for explanation of positions and have the students fill in their GR's.

1. Routine mastoids

a. Bi-lateral, Law's mastoids

NOTE: On Law's lateral mastoid the median plan is 15° facedown to prevent (side up) from overlying the area of consideration (side down).

NOTE: Stress that the side that is down is the side under consideration.

QUESTION: If the patient is in a right lateral position, which side is under consideration?

ANSWER: The right side.

b. Hickey's AP oblique (bi-lateral)

NOTE: Stress that the side that is up is the side under consideration on the AP view.

QUESTION: If the patient is in the Hickey's RPO position, which side is under consideration?

ANSWER: The left side.

2. Routine temporomandibular joints--Schuller's bi-lateral (open and closed)

NOTE: Emphasize that four exposures are taken--bi-lateral open mouth and bi-lateral closed mouth.

C. Demonstrate positions using information in Annexes A through C.

NOTE: Positions will be demonstrated by the instructor using a student from the class as a patient and refer students to the order of procedure.

1152

LP 38-520-068
076

QUESTION: What is the CRPR for Law's mastoid?

ANSWER: Tragus side down projected to center of film.

QUESTION: What is the angle and direction of CR for a Hickey's mastoid?

ANSWER: 15° caudad..

QUESTION: What is the angle and direction of CR for the open mouth right lateral TMJ?

ANSWER: 25° caudad.

D. Questions from Students

NOTE: Make study assignment: After class study TM 8-280, pp 10-92 and 10-93 and GR 38-520-027-1C.

III. SUMMARY (3 min)

A. Review of Main Points

1. Anatomical Structures

2. Positions

3. Demonstration

B. Closing Statement: The groundwork has now been laid with the first of numerous radiographic procedures of the skull's anatomical structures. It is vitally important that the accurate application of the two-way head alignment become routine with the X-Ray Specialist in order that diagnostic radiographs be produced on the very first try. Remember, preclude unnecessary radiation to your patient by getting it right the very first time.

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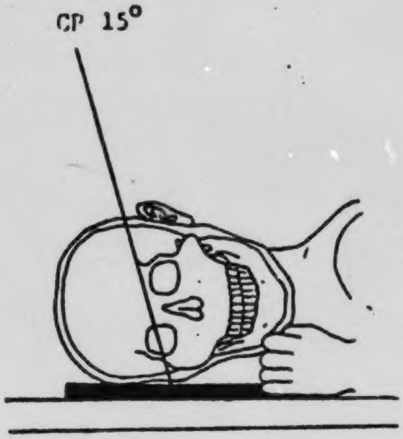
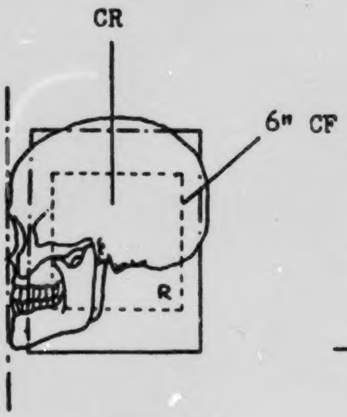
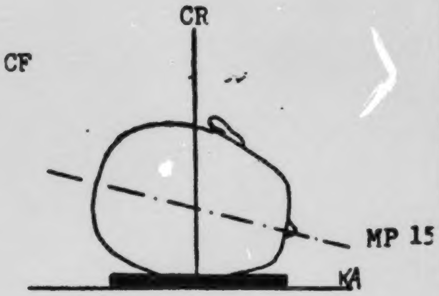
Mastoid

Routine: Law's and Hickey's (Bi-lateral)







Mastoid position: Law's

CRPR: Tragus of side nearest film projected to center of film holder

Film rundown: 8 x 10, L W, B ID: Correct letter marker in conefield

CR: 15° Caudad Cone: 6 "

TWHA: Median plane 15° facedown, facial plane parallel to lateral film border

Breathing Technique: Suspended Respiration FFD: 40 "

Demonstrates: Mastoid air cells

Notes: 1. Side closest to film is under consideration

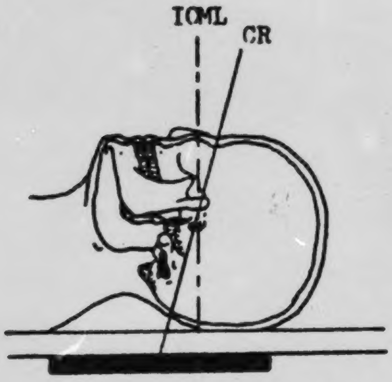
2. Remove all artifacts; earrings, hairpins, dentures etc.

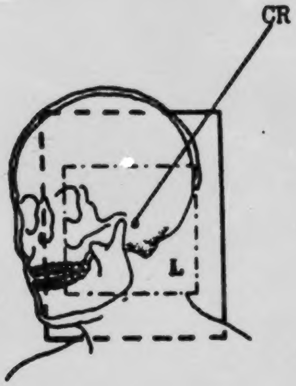
TM 8-280 pp. 10-92 Figure 10-86

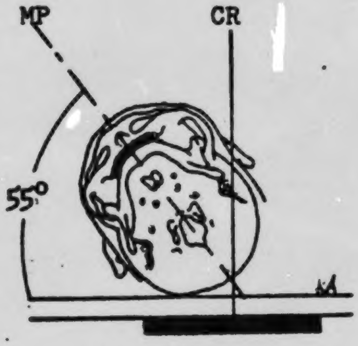
INSTRUCTIONAL AIDS

Mastoid

Routine: Law's and Hickeys (Bi-lateral)







Mastoid position: Hickey's

CRPR: Tragus of side farthest from film projected to center of film holder

Film rundown: 8 x 10, L W, B ID: Correst letter marker in conefield

CR: 15° Caudad Cone: 6 "

THHA: Median plane 55° to film. Infraorbital meatal line perpendicular to film

Breathing Technique: Suspended Respiration FFD: 40 "

Demonstrates: Mastoid air cells

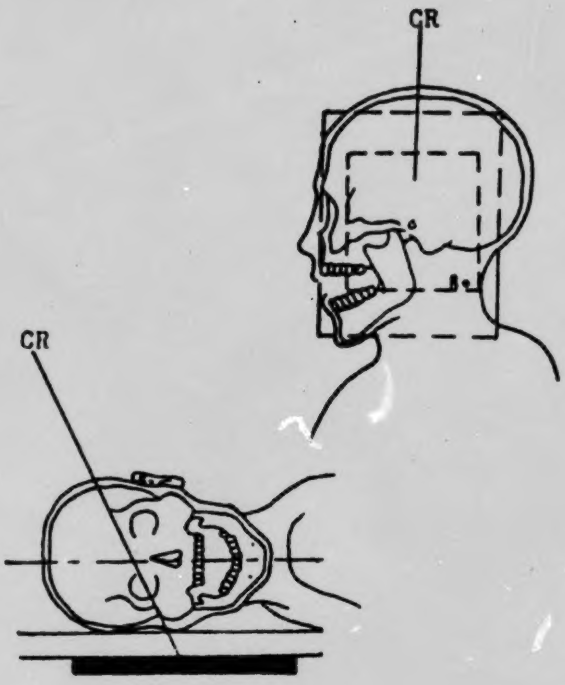
Notes: 1. Side up is under consideration

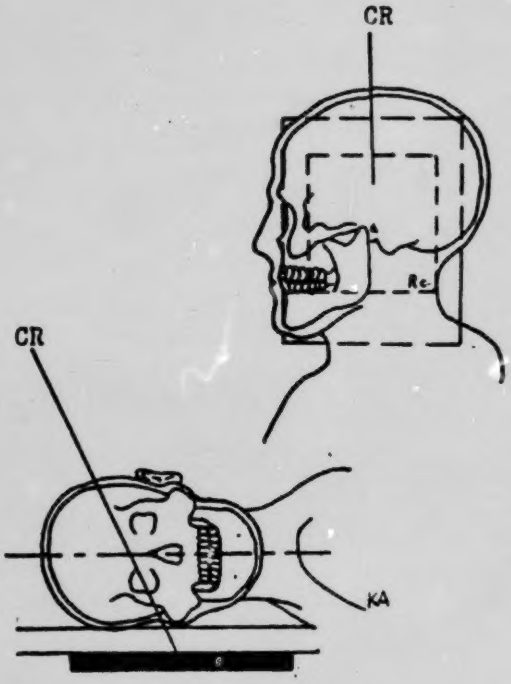
2. Remove all artifacts, earrings, hairpins, dentures etc.

TM 8-280 pp. 10-93 Figure 10-87

INSTRUCTIONAL AIDS
Temporomandibular Joint

Routine: Schuller's Bilateral Open and Closed





TMJ position: Schuller's open and closed

CRPR: Tragus of side nearest the film projected to center of film holder

Film rundown: 8 x 10, L W, B ID: Correct letter marker and open (O) or closed (C) in conefield

CR: 25° Caudad Cone: 6 "

TWHA: Median plane parallel to film, and Facial plane parallel to lateral film border

Breathing Technique: Suspended Respiration FFD: 40 "

Demonstrates: Temporomandibular joints

Notes: 1. Side closest to film is under consideration

2. Remove all artifacts; earrings, hairpins, dentures etc.

1156

SFC JIMMIE BINKLEY
*LP 38-520-069
076

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

Positioning of Skull: Nose and Facial Bones (1 hour)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES:

TM 8-280, pp 10-98 and 10-107.
Merrill, Vinita. Atlas of Roentgenographic Positions. 3d ed., Vol. II. St. Louis, Missouri: C.V. Mosby Company, 1967, pp 324, 325, 442, 446-449.

STUDY ASSIGNMENT: After class study TM 8-280, pp 10-98, 10-107, and GR 38-520-027-1C.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 and GR 38-520-027-1C

TOOLS, EQUIPMENT, AND MATERIALS: GR 38-520-027-1C issued at beginning of ninth week

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Radiographs of the nose and facial bones; pointer and x-ray illuminator; chalkboard, chalk, and eraser; PA system with legal mike (see Annexes A thru C).

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

I. INTRODUCTION (5 min)

A. Opening Statement: Because of the numerous bones and underlying anatomical structures, it is nearly impossible to visualize specific structures under consideration in the skull and facial bones. Therefore, two-way head alignment and correct part-to-film reference is necessary. Good radiographic techniques and correct positioning allow the Radiologist to make an unquestionable diagnosis.

---

*This lesson plan supersedes LP 38-520-069, 094.

B. Objectives

1. Identify by name the position and anatomical structures demonstrated of the routine nose and facial bones.

2. State the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization, film identification and captioning necessary to demonstrate the position(s) of the routine nose and facial bones.

3. Given a request slip and a simulated patient in the x-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which could produce a technically acceptable radiograph(s) of the routine nose and facial bones.

C. Class Procedure and Lesson Tie-in

1. Students will gather around the x-ray table during the demonstration.

2. Students will be demonstrating these positions in their laboratory practical exercise on crucial objectives.

II. DEMONSTRATION (35 min)

A. Anatomical Structures Demonstrated -- Nose and Facial Bones

NOTE: Place radiographs on viewbox and point out the following anatomical structures.

1. Nasal septum
2. Nasal bones - lateral view
3. Orbits
4. Zygoma
5. Maxilla
6. Sinuses

B. Positions

NOTE: Refer to Annexes A thru C for Explanation of positions and have the students fill in their GR's.

1. Lateral nose view (routine)

1158

NOTE: Bilateral view in lateral position.

QUESTION: How many exposures are taken of a lateral nose, and on what size film?

ANSWER: Two (bilateral) and on an 8 by 10, CW, NB.

NOTE: Patient should be instructed not to swallow.

2. Facial bones

   a. Waters' view (routine)

   b. Lateral view (routine)

NOTE: Patient is prone with chin on table for Waters' Facial View.

QUESTION: What is the angle and direction of the CR for the Waters' facial bones?

ANSWER: Vertical perpendicular.

NOTE: Patient is prone on table with his head turned to one side for lateral facial view.

C. Demonstrate positions using information in Annexes A thru C.

NOTE: Positions will be demonstrated by the instructor using a atudent from the class as a patient and refer students to the order of procedure.

QUESTION: What is the TWHA for lateral facial bones?

ANSWER: Median plane parallel to film AML parallel with lower film border.

D. Questions From Students

NOTE: Make study assignment: After class study TM 8-280, pp 10-98, 10-107 and GR 38-520-027-1C.

III. SUMMARY (5 min)

A. Review of Main Points

   1. Anatomical Structures

   2. Positions

   3. Demonstration

1160

B. Closing Statement: Due to the precision necessary for demonstrating the desired anatomy, the X-Ray Specialist must utilize his knowledge and equipment to the utmost. Inaccurate positioning may require length study by the Radiologist and possible repeats as the end result.

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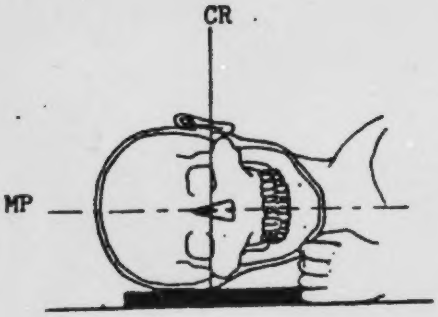
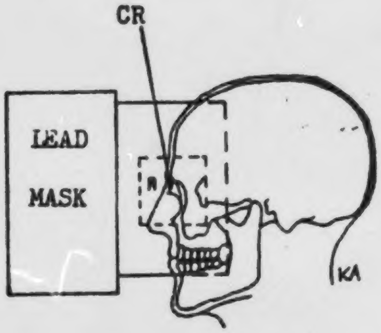
Routine: Bi-Lateral





Nose position: Lateral

PFR: Midpoint of nasal bones to center of film holder

Film rundown: 8 x 10, C W, NB, ID: Correct marker anterior to part

CR: V P Cone: 4"

TWHA: Median plane parallel to film, and Facial plane parallel with the lateral film holder

Breathing Technique: Suspended Respiration FFD: 40"

Demonstrates: Nasal bones in lateral position

Notes: 1. Ensure markers L and R appear on respective views in conefield

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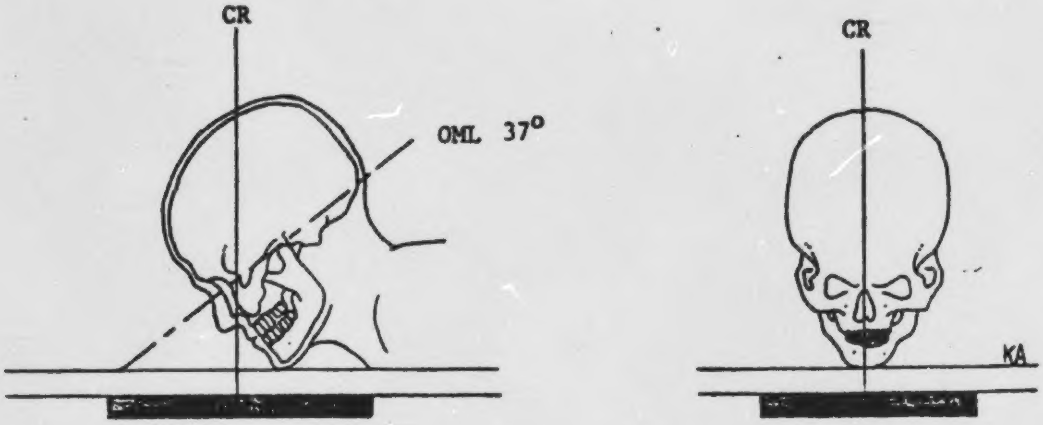
ANNEX B
INSTRUCTIONAL AIDS

Facial Bones

Routine: Waters and Lateral



Facial Bones Position: Waters

PFR: Acanthion to center of film holder

Film Rundown: 10 x 12, L W, B **ID:** Either lateral border

CR: V P **Cone:** FFC

TWHA: Median plane perpendicular, and Orbital meatal line forms a 37° angle to film

Breathing Technique: Suspended Respiration **FFD:** 40 "

Demonstrates: Facial and nasal bones

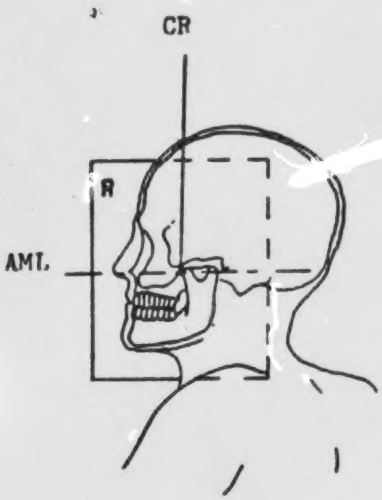
Notes: Artifacts: Before positioning patient, ensure eyeglasses, dentures, hairpins, earrings, etc. have been removed for all skull positions.

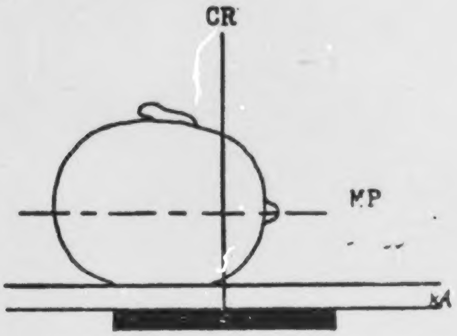
1163

TM 8-280 pp. 10-98 Figure 10-91

1162

Routine: Waters and Lateral





Facial Bones position: Lateral

PFR: Midpoint of Acanthio-Meatal line to center of film holder

Film rundown: 8 x 10, L W, B ID: Lateral border anterior to part

CR: V P Cone: FFC

TWHA: Median plane parallel to table, and Acanthio-Meatal line parallel to lower film border

Breathing technique: Suspended Respiration FFD: 40"

Demonstrates: Facial and nasal bones laterally

Notes: Artifacts: Before positioning patient, ensure eyeglasses, dentures, hairpins, earrings, etc. have been removed for all skull positions.

TM 8-280 pp. 10-98 Figure 10-91

1163

SFC JIMMIE BINKLEY
*LP 38-520-070
076

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

Positioning of the Skull: Petrous Ridges (2 hours)

COURSES PRESENTED TO: Radiographic Procedures (Basic) 313-91P20

PLACE: Classroom

REFERENCES:

TM 8-280. pp 19-94 and 10-95.
Merrill, Vinita. Atlas of Roentgenographic Positions. 3d ed. Vol II. St. Louis, Missouri: The C.V. Mosby Company. 1967. pp 320, 321, 400-404.

STUDY ASSIGNMENT: After class study TM 8-280, pp 10-94, 10-95, and GR 38-520-027-1C.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 and GR 38-520-027-1C.

TOOLS, EQUIPMENT, AND MATERIALS: GR 38-520-027-1C issued at beginning of ninth week.

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Radiographs of Arcelin's petrous ridges, Mayer's petrous ridges, and Stenver's petrous ridges; X-ray illuminators and pointer; chalkboard, chalk, eraser; PA system with lapel mike (see Annexes A thru D)

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

I. INTRODUCTION (5 min)

A. Opening Statement: You all have seen people who are drunk and you know how they stumble when they walk. This could also be a symptom of a patient who comes to your clinic for X-ray studies of the petrous ridges, only his stumbling and awkwardness will probably be a disorder of the semicircular canals which control equilibrium. You may be called upon to take films of petrous ridges in any clinic, and your positioning skills will determine the quality of the resulting film.

---

*This lesson plan supersedes LP 38-520-070, 074.

B. Objectives

1. Identify by name the positions and anatomical structures demonstrated of the routine views of the petrous ridges.

2. State the correct routine, PFR/DRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization, film identification and captioning necessary to demonstrate the position(s) of the petrous ridges.

3. Given a request slip and a simulated patient in the x-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiograph(s) of the petrous ridges.

C. Class Procedure and Lesson Tie-in

1. Students will gather around the x-ray table during the demonstration.

2. Students will be demonstrating these positions in their laboratory practical exercise on crucial objectives.

II. DEMONSTRATION (30 min)

A. Anatomical Structures Demonstrated -- Petrous Ridges

NOTE: Place radiographs on viewbox and point out following anatomical structures.

1. Mastoid air cells

2. Petrous ridge

    a. Auditory ossicles

    b. Semicircular canals

3. External acoustic meatus

4. Infraorbital meatal line

NOTE: Using dry skull, point out location of petrous ridges, 90 degree angle formed by them if they were extended to meet, and how median plane must be at 45 degree angle to make petrous ridge parallel to film.

QUESTION: What two structures are found in petrous ridge?

ANSWER: (1) Auditory ossicles, and (2) semicircular canals.

B. Positions

NOTE: Refer to Annexes B thru D for explanation of positions and have the students fill in their GR's.

1. Bilateral, Stenver's (routine)
2. Bilateral, Arcelin's (routine)
3. Bilateral, Mayer's (routine)

NOTE: Petrous portion of the Temporal bone contains the essential organs of hearing and balance, and the Arcuate Eminence denotes the specific structure under which the semicircular canals reside.

NOTE: Emphasize that the TWHA, FRD, Conefield and breathing technique for the views taught are the same.

QUESTION. How many views are needed to complete the routine?

ANSWER: Six (6) views.

C. Demonstrate positions using the information in Annexes B thru D.

NOTE: Positions will be demonstrated by the instructor using a student from the class as a patient and refers students to the order of procedure.

D. Questions From Students

NOTE: Make study assignment: After class study TM 8-280, pp 10-94, 10-95, and GR 38-520-027-1C.

III. SUMMARY (5 min)

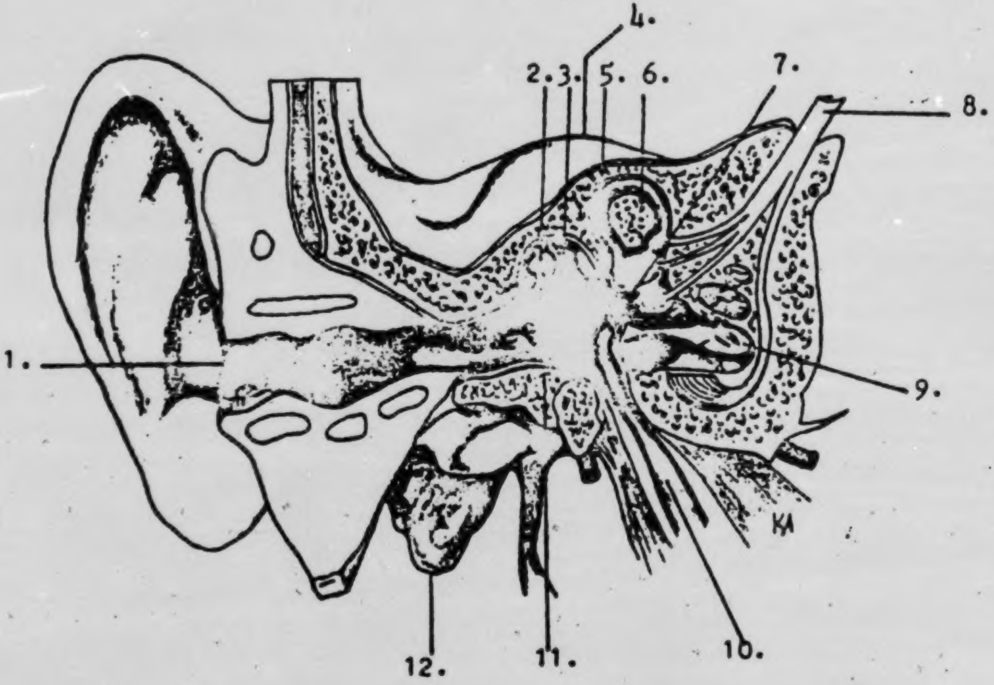
A. Review of main points.

1. Anatomical Structures
2. Positions
3. Demonstration

B. Closing Statement: Keep in mind that the petrous portion of the skull is yet another area that will require extremely accurate positioning to produce satisfactory demonstrations. The radiographic procedure, once thoroughly understood, is not unduly difficult but rather a challenge to your ability as an X-Ray Specialist.

1166

ANNEX A
INSTRUCTIONAL AIDS

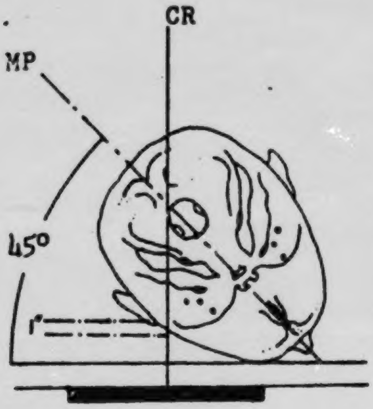


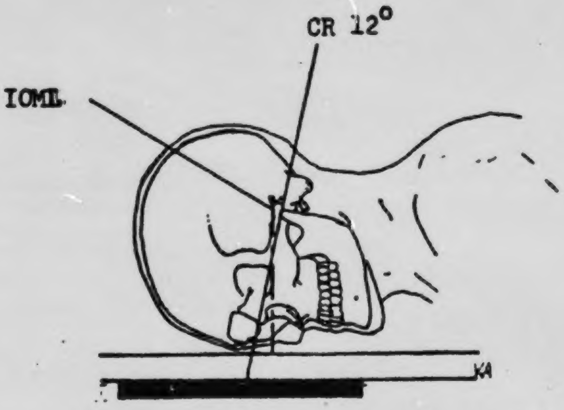
1. External Auditory Meatus
2. Malleus
3. Incus
4. Arcuate Eminence
5. Stapes
6. Semi-circular Canal
7. Oval Window
8. Eighth Nerve
9. Cochlea
10. Eustachian Tube
11. Tympanic Membrane
12. Mastoid Tip

INSTRUCTIONAL AIDS

Petrous Ridges

Routine: Bilateral Arcelin's, Stenver's, and Mayer's





Petrous ridge position: Stenver's

CRPR: A point 1" anterior to tragus of side closest to film along Infraorbital meatal line to center of film holder

Film rundown: 8 x 10, L W, B ID: Corresponding letter marker in conefield

CR: 12° Cephalic Cone: 6 "

TWHA: Median plane 45° to film ,

and Infraorbital meatal line perpendicular to film.

Breathing technique: Suspended Respiration FFD: 40 "

Demonstrates: Petrous ridge closest to film, Mastoid antrum and internal auditory meatus

Notes: 1. Side down is under consideration

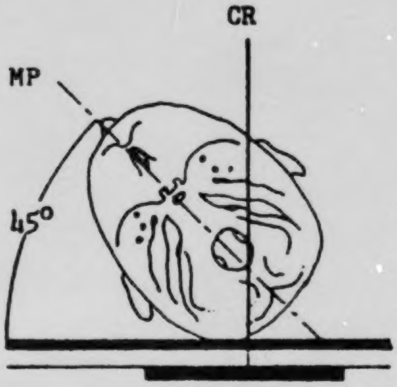
2. Patient prone; three-point landing-- nose, cheek and forehead to table.

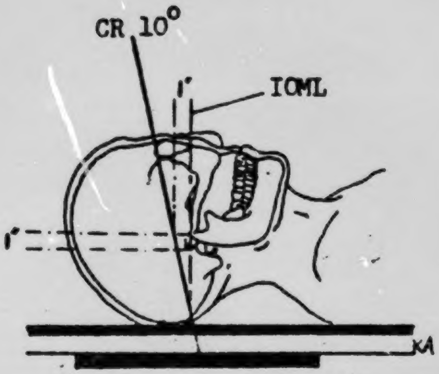
3. Remove artifacts- necklaces, dentures, earrings, hairpins etc.

TM 8-280 pp. 10-94 Figure 10-88

INSTRUCTIONAL AIDS
Petrous Ridges

Routine: Bilateral Arcelin's, Mayer's and Stenver's





Petrous ridge position: Arcelin's

CRPR: A point 1" anterior and 1" superior to tragus of side up along Infraorbital meatal line projected to center of film holder

Film rundown: 8 x 10, L W , B **ID:** Corresponding letter marker in conefield

CR: 10° Caudad **Cone:** 6 "

TWHA: Median plane 45°

and Infraorbital meatal line perpendicular to film.

Breathing technique: Suspended Respiration **FFD:** 40 "

Demonstrates: Petrous ridge farthest from film, mastoid antrum, internal auditory meatus

Notes: 1. Patient supine

2. Side up is under consideration

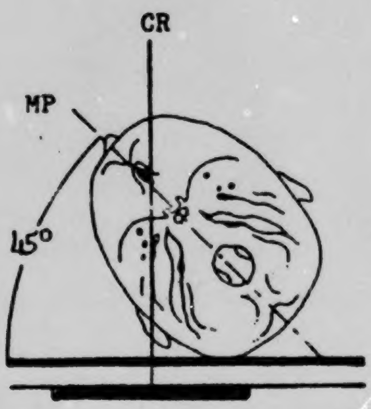
3. Remove artifacts- hairpins, earrings, dentures etc.

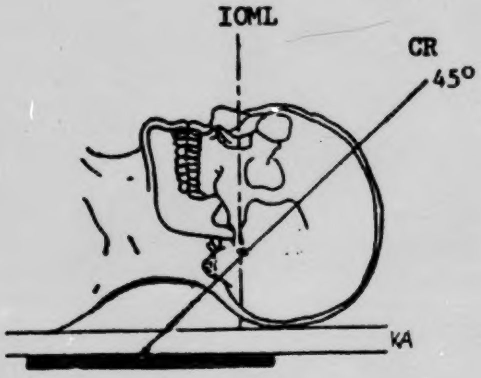
4. Arcelin's is a reverse stenver's

TM 8-280 pp. 10-94 Figure 10-88

Petrous Ridges

Routine: Bilateral Maver's, Arcelin's and Stenver's





Petrous ridge position: Mayer's

CRPR: Tragus of side closest to film projected to center of film holder

Film rundown: 8 x 10, L W, B **ID:** Corresponding letter marker in conefield

CR: 45° Caudad **Cone:** 6 "

TWHA: Median plane 45° to film ,

and Infraorbital meatal line perpendicular to film.

Breathing technique: Suspended Respiration **FFD:** 40 "

Demonstrates: Petrous ridge in direction of long axis, Mastoid antrum, internal and external auditory meati

Notes: 1. Patient supine

2. Side down is under consideration

3. Remove all artifacts - hairpins, earrings, eyeglasses, dentures etc.

TM 8-280 pp. 10-95 Figure 10-89

SFC JIMMIE BINKLEY
*LP 38-520-071
076

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

Positioning of the Skull: Zygomatic Arches and Rhese's Foramen (1 hour)

COURSES PRESENTED TO: Radiographic Procedures (Basic), 313-91P20

PLACE: Classroom

REFERENCES:

TM 8-280, pp 10-91 and 10-106.
Merrill, Vinita. Atlas of Roentgenographic Positions. 3d ed., Vol. II. St. Louis, Missouri: C.V. Mosby Company, 1967, pp 352-353, 450-457.

STUDY ASSIGNMENT: After class study TM 8-280, pp 10-91, 10-106 and GR 38-520-027-1C.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 and GR 38-520-027-1C.

TOOLS, EQUIPMENT, AND MATERIALS: GR 38-520-027-1C issued at beginning of ninth week.

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Radiographs of Rhese's optic foramen, zygomatic arches; pointer and illuminator; chalkboard, chalk, and eraser; PA system with lapel mike.

TROOP REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

I. INTRODUCTION (2 min)

A. Opening Statement: Jug handles and little holes! Better known in medical terminology as zygomatic arches and optic foramen. These are certain selected views not done routinely. When performed properly, the zygomatic arches give the appearance of two jug or cup handles, hence the expression. If the optic foramen is not open on the radiograph, you have an unsatisfactory examination. As you become more familiar with these examinations, you will be aiding and assisting your radiologist by producing clinically acceptable radiographs.

---

*This lesson plan supersedes LP 38-520-071, 074.

B. Objectives

1. Identify by name the position and anatomical structures demonstrated of the zygomatic arches and the routine Rhese's optic foramen.

2. State the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique immobilization, film identification and captioning necessary to demonstrate the position(s) of the zygomatic arches and the Rhese's optic foramen.

3. Given a request slip and a simulated patient in the x-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiograph(s) of the zygomatic arches and the Rhese's optic foramen.

C. Class Procedure and Lesson Tie-in

1. Students will gather around the x-ray table during the demonstration.

2. Students will be demonstrating these positions in their laboratory practical exercise on crucial objectives.

II. DEMONSTRATION (40 min)

A. Anatomical Structures Demonstrated -- Zygomatic Arches and Optic Foramen

1. Orbit

2. Sphenoid

3. Optic Foramen

4. Temporal Process

5. Frontal Process

6. Zygomatic Arches

B. Positions

NOTE: Refer to Annexes A and B for explanation of positions and have the students fill in their GR's.

1. Rhese Optic Foramen -- PA (Oblique) Routine Bilateral

NOTE: Side under consideration is down on table top.

2. Submentovertical Zygomatic Arches

QUESTION: Why do we include both right and left optic foramens?

ANSWER: For comparison; rules out peculiarities existing in the individual.

QUESTION: What is the two-way head alignment for the submentovertical zygomatic arches view?

ANSWER: Median plane perpendicular to film and infraorbitomeatal line parallel to the film.

C. Demonstrate positions using information in Annexes A and B.

NOTE: Positions will be demonstrated by the instructor using a student from the class as a patient and refer students to the order of procedure.

D. Questions From Students

NOTE: Make study assignment: After class study TM 8-280, pp 10-91, 10-106, and GR 38-520-027-1C.

III. SUMMARY (3 min)

A. Review of Main Points

1. Anatomical Structures

2. Positions

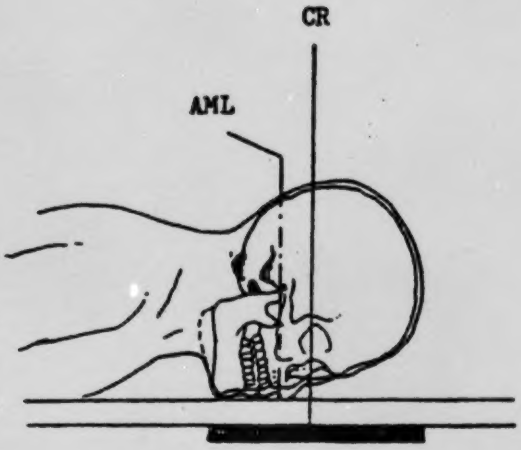
3. Demonstration

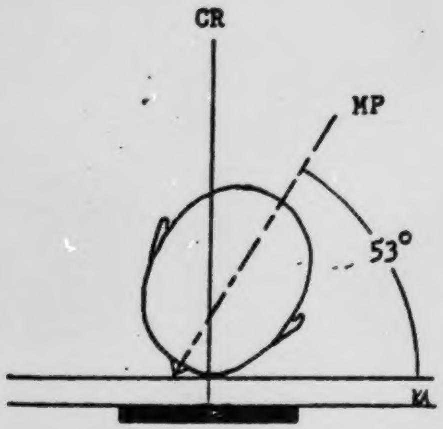
B. Closing Statement: Because Rhese's Foramen and Zygomatic Arches may not be ordered routinely in X-ray clinics the requirement of exact positioning remains nevertheless. You, the Technologists, must maintain a thorough knowledge of the Anatomy in addition to positioning skills in order to produce the very best quality radiographs of these procedures.

076-1173

INSTRUCTIONAL AIDS

PA (Oblique) Optic Foramen, Rhese Position





PFR: Orbit of side under study centered to film holder

Film rundown: 8 x 10, L W, B ID: Correct letter marker in conefield

CR: V P Cone: 6"

TWHA: Median plane 53° to table, and Acanthiomeatal line perpendicular to film.

Breathing technique: Suspended Respiration FFD: 40"

Demonstrates: Optic foramen, Posterior ethmoidal and sphenoidal sinuses

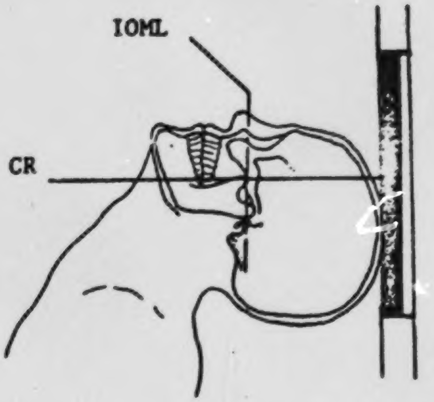
Notes:

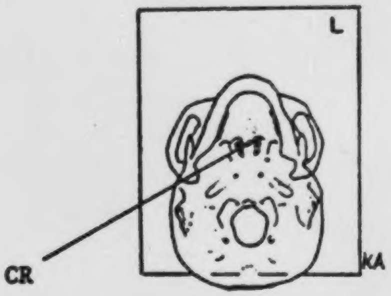
1. Three point landing - nose, cheek and chin on table.
2. Object is to get optic foramen perpendicular to film so CR goes straight down through it.
3. Remove artifacts - hairpins, eyeglasses, dentures, earrings etc.

TM 8-280 pp. 10-91 Figure 10-85

INSTRUCTIONAL AIDS 076 1174

Submentalvertical Zygomatic Arches Position





PFR: Midpoint of Infraorbital meatal line to center of film holder

Film rundown: 10 x 12, L W, B ID: Correct letter marker either lateral border

CR: H P Cone: FFC

TWHA: Median plane perpendicular, and Infraorbital meatal line parallel to film

Breathing technique: Suspended Respiration FFD: 40 "

Demonstrates: Zygomatic arches

Notes: 1. Both zygomatic arches demonstrated on same film

2. Remove artifacts - hairpins, earrings, eyeglasses, dentures etc.

3. VARIATIONS: see TM 8-280 Ch 10 pg. 106

4. Technical factors reduced from Bowen-Hirtz skull, to avoid overpenetrating the zygomatic arches

B-1176

ACADEMY OF HEALTH SCIENCES US ARMY

SFC J. BINKLEY
SFC R. GORDON

*GR 38-520-027-1
047

X-RAY BRANCH

TO CONSERVE FIGHTING STRENGTH

313-91P10

RADIOGRAPHIC POSITIONING
VOLUME I
UPPER EXTREMITY

MEDICINE AND SURGERY DIVISION
X-RAY BRANCH
FORT SAM HOUSTON, TEXAS 78234

*This general reference supersedes GR 38-520-027-1, 116

1176

TABLE OF CONTENTS

UPPER EXTREMITY

	PAGE
Introduction and Terminology of Positions	1 - 4
Factor Chart	5, 6
Film Identification: Captioning	7 - 9
Order of Procedure	10, 11
Objectives	12
Positioning of the Hand - Posterior Anterior	13
Positioning of the Hand - Oblique	14
Positioning of the Hand - Lateral	15
Positioning of the Hand - Lateral (Splayed Fingers)	16
Positioning of the Wrist - Posterior Anterior	17
Positioning of the Wrist - Ulnar Flexion	18
Positioning of the Wrist - Oblique	19
Positioning of the Wrist - Lateral	20
Positioning of the Forearm - Anterior Posterior (Distal)	21
Positioning of the Forearm - Lateral (Distal)	22
Positioning of the Forearm - Anterior Posterior (Proximal)	23
Positioning of the Forearm - Lateral (Proximal)	24
Positioning of the Elbow - Anterior Posterior	25
Positioning of the Elbow - Lateral	26
Positioning of the Elbow - Jones View	27
Positioning of the Humerus - Anterior Posterior (Distal)	28
Positioning of the Humerus - Lateral (Distal)	29
Positioning of the Full Length Humerus - External Rotation	30
Positioning of the Full Length Humerus - Internal Rotation	31
Positioning of the Humerus - Trans Thoracic	32
Positioning of the Shoulder - Internal Rotation	33
Positioning of the Shoulder - External Rotation	34
Positioning of the Shoulder Joint - Superior Inferior	35
Positioning of the Shoulder Joint - Inferior Superior	36
Positioning of the Clavicle - Posterior Anterior	37
Positioning of the Clavicle - Posterior Anterior 20° Caudad	38
Positioning of the Scapula - Anterior Posterior	39
Positioning of the Scapula - Lateral	40

Introduction and Terminology of Positions

1. Objectives

   a. Recognize and relate radiographically the concepts of right angle viewing of radiographs.

   b. Recognize terms used in the naming of positions and the positioning of the patient.

   c. Recognize terms used in the explanation, demonstration, and application of positions.

   d. Given a position, set up proper machine factors from the factor chart.

2. Right angle radiographic viewing.

   a. Concepts (three dimensional)

   b. Radiographic visualization

      (1) Posterior-anterior (PA) view

         (a) Height - Superior to Inferior

         (b) Width - Lateral to Lateral

      (2) Lateral View

         (a) Height - Superior to Inferior

         (b) Length - Anterior to Posterior

If lateral cannot be accomplished for a right-angle projection to the PA or AP view, the next choice would be an oblique view.

3. Naming positions

   a. Entry-Exit surface of the central ray.

   b. Anatomical surface nearest the film.

   c. The author or originator.

   d. Anatomical structure demonstrated.

4. Positioning terminology

   a. PA—AP

   b. Lateral

   c. Obliques

   d. Specific Obliques

      (1) RAO - Right Anterior Oblique

      (2) RPO - Right Posterior Oblique

      (3) LAO - Left Anterior Oblique

      (4) LPO - Left Posterior Oblique

   e. Supine—prone

   f. Recumbent—decubitis

The following terms are used daily in the explanation, demonstration and in the application of radiographic positions.

Routine:

> Refers to the necessary radiographic positions or views needed to accomplish right—angle viewing and/or a general survey of the anatomical part to be demonstrated.

Additional views:

> Positions or views in addition to the routine for a more thorough visualization of the part and/or specific structures.

PFR (Part to Film-Holder Reference):

> Refers to the specific placement of a palpation point or anatomical part on the film holder to properly demonstrate the part.
>
> EXAMPLE: To demonstrate the lateral view of the hand the PFR would be: The head of the secpnd metacarpal to center of the film (holder).

CRPR (Central Ray to Part Reference):

> Relates to the specific placement of the central-ray to an anatomical part or palpation point thereby projecting that part or point to center of the film (holder).

F[illegible] Rundown:

Refers to the film holder requirements for a procedure (routine or additional views) with reference to the film holder size (8 x 10, 10 x 12, or 14 x 17); the film holder placement in relation to the anatomical part lengthwise (LW), or crosswise (CW), and whether the use of a Bucky (B) or non-Bucky (NB) accessory is necessary.

EXAMPLE: The routine forearm film rundown is: 10 x 12, LW, NB.

CR (Central Ray):

Refers to the angle and direction of the central ray (CR) with relation to the film holder or other reference. The central ray is always to center of the film area to be exposed whether a PFR or CRPR is used. When using a PFR, the CR is positioned to strike the center of the film being exposed. For CRPR's the film is adjusted so the CR would strike center of the film to be exposed.

Conefield:

Reference to the film area being exposed by the primary x-ray beam.

1. Film coverage--any area being exposed whether it be 1/4, 1/3, 1/2, or the whole film holder; thus, the conefield requirements for the PA hand would be film coverage.

2. All other conefields--the size of the diameter of the field will be specified.

EXAMPLE: The conefield requirements for the open-mouth cervical is specified as six inches.

FFD (Focal Film Distance):

Measured distance in inches between the tube focal spot and the film holder. The following applies:

- Table-top procedures--FFD is measured through the film holder to the table top.

Bucky procedures--FFD is measured to table top at a measurement allowing two inches to the Bucky tray. For example: If a 40 inch FFD is required for a Bucky technique, a measured distance of 38 inches to the table top is set; thus leaving two inches from the table top to Bucky tray where the film holder is placed resulting in a total distance of 40 inches FFD.

Breathing Technique:

Required instructions given to the patient prior to making the exposure. Following the exposure, it should always be remembered that the patient be instructed to breath normally. The types of breathing instructions are as follows:

1. Suspended Respiration--Patient instructed to stop breathing at anytime.

2. Suspended Inspiration--Patient instructed to take in a deep breath and hold in the breath during the exposure.

3. Suspended Expiration--Patient instructed to take in a breath and let his breath out and holding out his breath during the exposure.

Demonstrates:

Refers to the primary and surrounding anatomical structures that are demonstrated on the radiograph.

Alignment:

The necessary position of certain anatomical structures and/or anatomical planes relationship to the film, other anatomical planes, etc.--to properly demonstrate the part.

EXAMPLE: To properly demonstrate the AP elbow, the epicondyles of the humerus must be parallel to the film.

Cassette:

Refers to film holder. In x-ray, the cassette is a special type of holder. Generally, the top of the cassette is black (bakelite) framed by a metal border. In the use of PFR's the metal border is included in the measurement. Conefields also include the exposing metal borders. Cassettes with bakelite tops of other colors (generally orange or red) are grid cassettes where the grid is included in the bakelite. These should be compensated for in technique as for Bucky procedures.

ACADEMY OF HEALTH SCIENCES, US ARMY
MEDICINE AND SURGERY DIVISION
X-RAY BRANCH
FORT SAM HOUSTON, TEXAS 78234

Optimum kVp Technic Chart 100 mA, 100 kVp Field Unit

This Optimum kVp Technique Chart is primarily for use with the full wave rectified 100 mA, 100 kVp, (stationary anode) field unit with the Army field table. Film holders on this chart are cassettes with high speed screens. The Bucky used is 6:1 where indicated by a "B" in the last column. An asterisk (*) indicates non-routine positions. A double asterisk indicates a position for which factor compensations for patients above the normal centimeter range will exceed tube limits. Use the blocked chart below to adjust for centimeter measurements above or below the centimeter range shown.

NOTE: This chart is valid for any radiographic unit when employing optimum kVp technique. Compensations for higher grid ratios should be made in kVp.

3-5 cm. below	1-2 cm. below	In range	1-2 cm. above	3-5 cm. above
1/2 x S	2/3 x S	basic S	basic S x 1 1/2	basic S x 2

PART	POSITION	FILM	CM	KV	FOCAL SPOT	MA	S	FFD	B	NB
HAND	PA	1/2 10C	2-4	50	Sm	25	.2	40		NB
	Oblique	1/2 10C	3-5	50	Sm	25	.2	40		NB
	Lateral*	1 8L	7-10	50	Sm	20	.6	40		NB
WRIST	PA	1/4 10C	3-5	50	Sm	25	.2	40		NB
	Oblique	1/4 10C	4-6	55	Sm	25	.2	40		NB
	Lateral	1/4 10C	5-8	50	Sm	20	.6	40		NB
	PA w/Ulnar flexion	1/4 10C	3-5	50	Sm	25	.2	40		NB
FOREARM	Dist, AP	1/2 10L	4-7	60	Sm	25	.2	40		NB
	Dist, Lateral	1/2 10L	6-9	60	Sm	25	.3	40		NB
	Prox, AP	1/2 10L	6-9	60	Sm	25	.3	40		NB
	Prox, Lateral	1/2 10L	7-10	60	Sm	25	.3	40		NB
ELBOW	AP	1/2 10C	6-9	60	Sm	25	.3	40		NB
	Lateral	1/2 10C	6-9	60	Sm	25	.3	40		NB
	Jones*	1 8L	8-11	60	Sm	25	.4	40		NB
HUMERUS	Dist, AP	1/2 10L	7-10	60	Sm	25	.3	40		NB
	Dist, Lateral	1/2 10L	7-10	60	Sm	25	.3	40		NB
	Full, AP, EX	1/2 14L	7-11	60	Sm	25	.3	40		NB
	Full, AP, IN	1/2 14L	7-11	60	Sm	25	.3	40		NB
	Trans Thoracic*	1 10L	35-40	80	Lg	100	1.5	40	B	

PART	POSITION	FILM	CM	KV	FOCAL SPOT	MA	S	FFD	B	NB
SHOULDER	AP, EX	1 10C	11-15	75	Sm	30	.3	40	B	
	AP, IN	1 10C	11-15	75	Sm	30	.3	40	B	
	Superoinferior*	1 8C	7-12	70	Sm	25	.1	40		
SCAPULA	AP	1 10L	13-17	75	Sm	30	.4	40	B	
	Lateral	1 10L	18-22	75	Sm	30	1.0	40	B	
CLAVICLE	PA, R-L	2 10C	11-15	75	Sm	30	.3	40	B	
FOOT	DP, Oblique	1 10L	6-9	60	Sm	30	.2	40		NB
OS CALCIS	Inferosuperior	1/2 10C	8-13	60	Sm	30	.3	40		NB
	Lateral	1/2 10C	5-8	60	Sm	30	.2	40		NB
ANKLE	AP	1/2 10C	8-11	60	Sm	25	.3	40		NB
	Oblique	1/2 10C	6-9	60	Sm	25	.2	40		NB
	Lateral	1 8L	6-9	60	Sm	25	.2	40		NB
LEG	Dist, AP	1/2 14L	8-11	65	Sm	25	.3	40		NB
	Dist, Lateral	1/2 14L	8-11	65	Sm	25	.3	40		NB
	Prox, AP	1/2 14L	10-13	65	Sm	30	.3	40		NB
	Prox, Lateral	1/2 14L	10-13	65	Sm	30	.3	40		NB
KNEE	AP, PA*	1 8L	10-13	65	Sm	30	.3	40		NB
	Lateral	1 8L	9-12	65	Sm	30	.3	40		NB
	Holmblad*	1 8L	12-16	75	Sm	25	.3	40		NB
	Beclere*	1 8C	12-16	75	Sm	25	.3	40		NB
	Settegast*	1 8L	11-15	70	Sm	25	.3	40		NB
FEMUR	Dist, AP & Lateral	2 14L	12-15	70	Sm	50	.4	40	B	
	Prox, AP & Lateral	2 14L	15-19	70	Sm	50	.6	40	B	
PELVIS	AP, Frogleg*	1 14C	17-21	65	Sm	50	1.25	40	B	
HIP	AP	1 10L	16-20	70	Sm	50	.8	40	B	
	Lateral	1 10C	22-26	85	Sm	50	.8	40	GC	
SACRUM	AP	1 10L	19-23	65	Sm	50	2	40	B	
	Lateral**	1 10L	29-33	80	Lg	100	2	40	B	
COCCYX	AP	1 8L	19-23	65	Sm	50	2	40	B	
	Lateral**	1 8L	29-35	80	Lg	100	2	40	B	
CERVICAL SPINE	AP	1 10L	10-12	80	Sm	25	.3	40	B	
	Open Mouth	1 8L	13-16	80	Sm	30	.4	40	B	
	Moving Jaw*	1 10L	10-12	55	Sm	10	3	40	B	
	Lateral	1 10L	10-12	85	Sm	25	.4	72		NB
	Oblique*	1 10L	10-12	80	Sm	30	.3	40	B	
	Flexion*	1 10L	10-12	85	Sm	25	.4	72		NB
	Extension*	1 10L	10-12	85	Sm	25	.4	72		NB

FILM IDENTIFICATION: CAPTIONING

1. Objectives

   a. Select the 9 items on the x-ray request slip (SF 519A) that must be filled out before it can be processed by the receptionist.

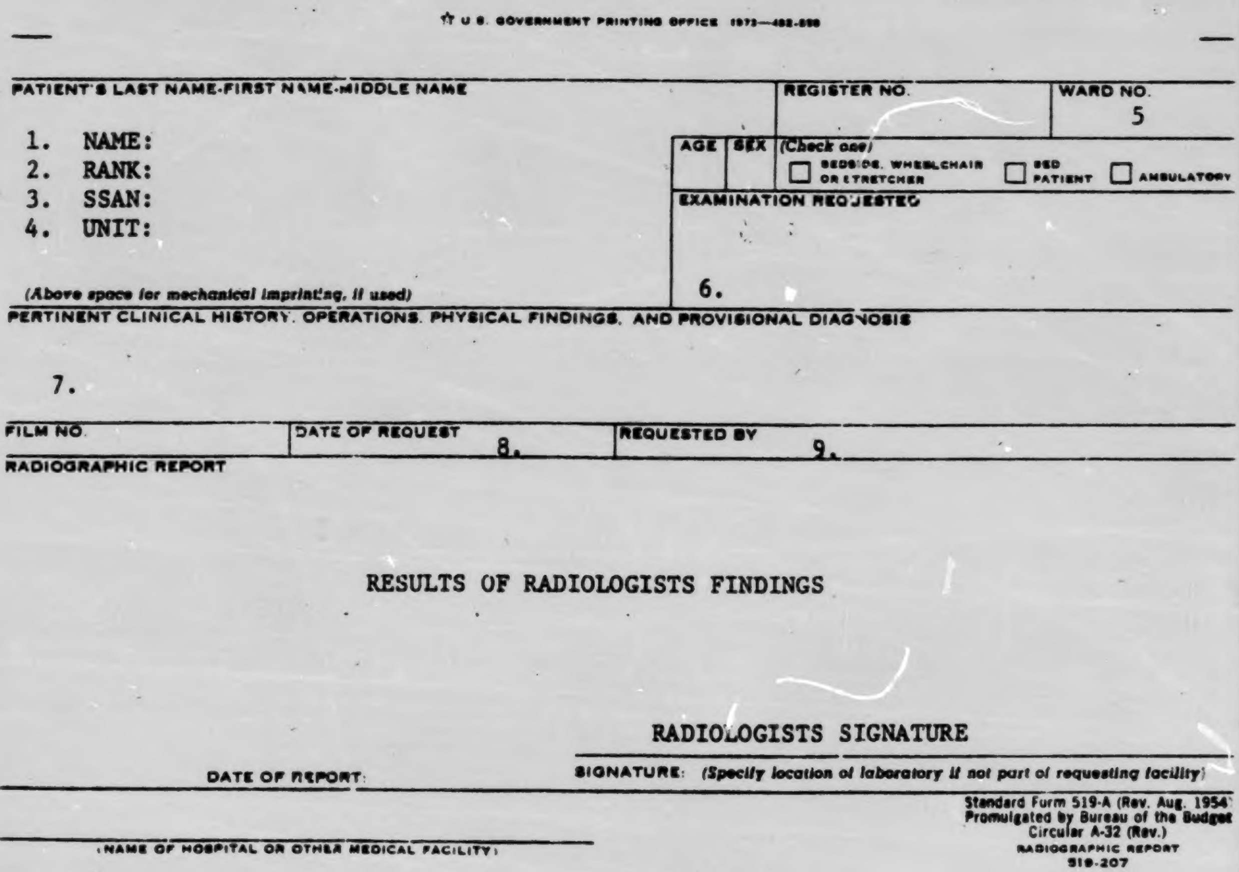
   b. Identify two primary methods of transmitting permanent identification to radiograph.

   c. Select the four items of patient information required to properly identify a radiograph.

   d. Given a description of a position, determine the proper letter marker to be used.

   e. Given radiographs of the trunk and skull, determine, by the letter marker, the position of the part.

2. Radiographic Report (SF 519A See Form Below)



☆ U.S. GOVERNMENT PRINTING OFFICE 1973—482-898

PATIENT'S LAST NAME-FIRST NAME-MIDDLE NAME 1. NAME: 2. RANK: 3. SSAN: 4. UNIT: (Above space for mechanical imprinting, if used)	AGE | SEX	REGISTER NO.	WARD NO. 5
		(Check one) ☐ BEDSIDE, WHEELCHAIR OR STRETCHER ☐ BED PATIENT ☐ AMBULATORY	
	EXAMINATION REQUESTED 6.		

PERTINENT CLINICAL HISTORY, OPERATIONS, PHYSICAL FINDINGS, AND PROVISIONAL DIAGNOSIS

7.

FILM NO.	DATE OF REQUEST	REQUESTED BY
	8.	9.

RADIOGRAPHIC REPORT

RESULTS OF RADIOLOGISTS FINDINGS

RADIOLOGISTS SIGNATURE

DATE OF REPORT:

SIGNATURE: (Specify location of laboratory if not part of requesting facility)

(NAME OF HOSPITAL OR OTHER MEDICAL FACILITY)

Standard Form 519-A (Rev. Aug. 1954)
Promulgated by Bureau of the Budget
Circular A-32 (Rev.)
RADIOGRAPHIC REPORT
519-207

3. Film Identification

A. Methods of transmission to film

(1) X-ray exposure

(2) Light

Additional way of transmitting identification on film is the written method. This method is primarily used in surgery and should be avoided if possible due to legal reasons.

B. Patient information required on film caption

(1) Name

(2) Age

(3) SSAN

Date on film caption is the date the film was taken.

(4) Date

(1) BROOKE GENERAL HOSPITAL
FORT SAM HOUSTON, TEXAS
(2) NAME ______________________ AGE ________
(3) SSAN ______________________________
(4) DATE ______________ STATUS ________

EXAMPLE X-RAY FLASH CARD

4. Determining proper letter marker

   a. Extremities - Corresponding:"R"for Right and "L" for Left.

   b. Trunk and skull

      (1) AP, PA, and OBL - Letter marker corresponds with the side of the body it is placed with.
      (2) LATERALS - Letter marker corresponds with the side of the body nearest the film.

   c. Conefields

      (1) Extremities - The rules above apply.

      (2) Skull and Trunk - The rules above apply except when individual structures are under consideration.

1186

Laboratory - Order of Procedure

1. Objectives

   a. Determine the X-Ray Technologist's role in performing a radiographic prodedure.

   b. Identify in sequence the order of procedure required for radiographic positioning.

   c. After practice apply the order of procedure in proper sequence while positioning the patient to produce diagnostic radiographs.

      I. Control Panel

         a. Measure part

         b. Set technique factors (MA, S, & KVP)

      II. Table Factors

         a. FRD & letter marker

NOTE: Put letter marker on film at this time.

         b. Set angle of tube

         c. Set FFD

      III. Position Patient

         a. PFR/CRPR

         b. Alignment

NOTE: At times it may be more advantageous to do alignment prior to doing PFR/CRPR.

         c. Align CR to center of film being exposed.

         d. Set proper conefield

NOTE: Check FFD, Letter Marker, and Conefield

      IV. Exposure

         a. Verify factors

         b. Give instructions to patient

         c. Make exposure

1188

NOTE: PAGE 1187 HAS BEEN DELETED; HOWEVER ALL MATERIAL HAS BEEN INCLUDED.

1188

OBJECTIVES

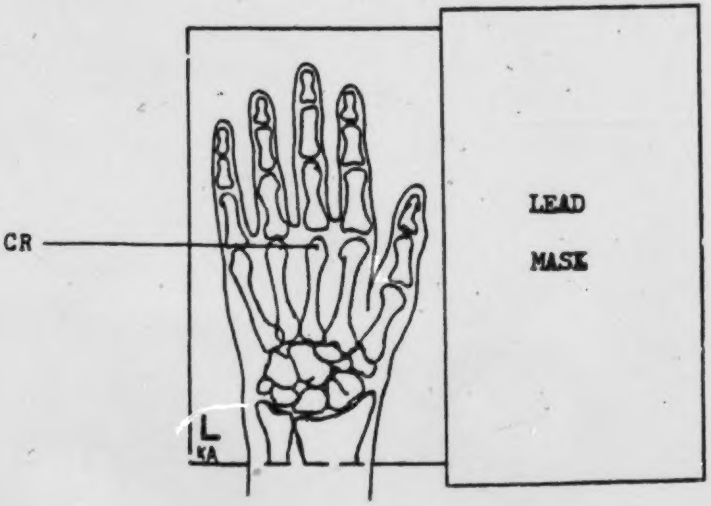
1. Identify by name the position and anatomical structures demonstrated.

2. Determine the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization, film identification and captioning necessary to demonstrate the position.

3. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiographic position.

Routine: PA and Oblique

Additional: Lateral



Hand Position PA

PFR: Head of the 3rd metacarpal to center of film

Film Rundown: 1 10 x 12 CW NB CR: VP Cone: FFC

Alignment: Palmar surface flat on film; fingers separated (part centered).

Demonstrates: Digits, metacarpals and carpals.

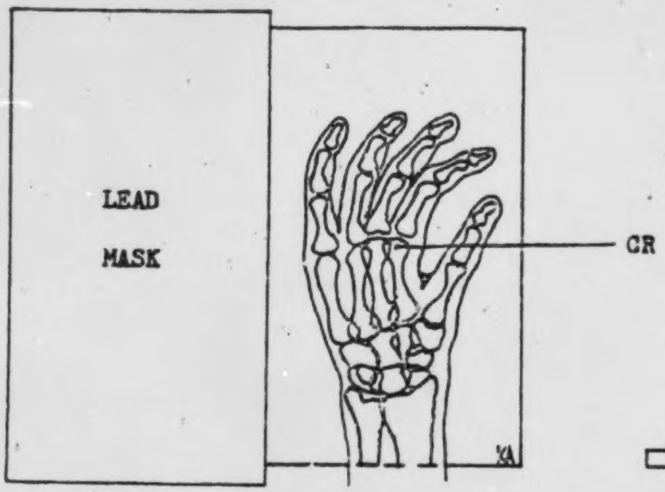
Notes: FFD: 40" ID: Above part reading down.

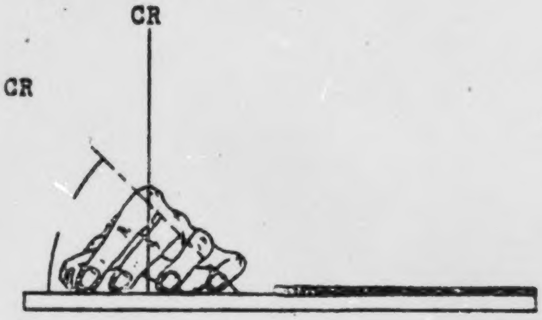
Immobilization: Place sandbags against forearm. Remove all artifacts (rings, watches, etc.).

Hand

Routine: PA and Oblique

Additional: Lateral





Hand Position Oblique

PFR: Head of 2nd metacarpal to center of film

Film Rundown: 1 10 x 12 CW NB CR: VP Cone: FEC

Alignment: Part centered; plane through heads of metacarpals forms a 45° angle to film.

Demonstrates: Digits, metacarpals and carpals

Notes: FFD: 40" ID: Above part reading down.

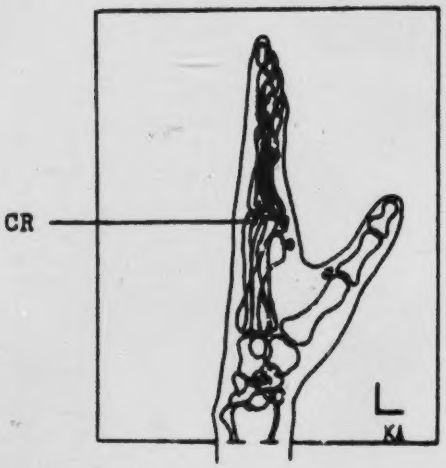
Immobilization: Place sandbags against forearm. Remove all artifacts (rings, watches, etc.).

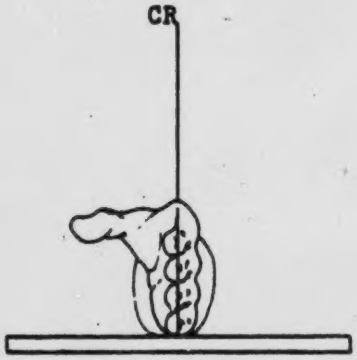
TM 8-280 pp. 10-9 Figure 10-4

Hand

Routine: PA and Oblique

Additional: Lateral





Hand Position Lateral

PFR: Head of 2nd metacarpal to center of film

Film Rundown: 1 8 x 10 LW NB CR: VP Cone: FEC

Alignment: Part centered with hand vertical and fingers extended.

Demonstrates: Primarily: Foreign body localization. Secondarily: Anterior or posterior displacement of metacarpals.

Notes: FFD, 40" ID: Either lateral border.

Immobilization: Place sandbags against forearm, and radiolucent material under thumb.

1) Bennetts' Fracture: A longitudinal fracture of the 1st metacarpal (thumb).

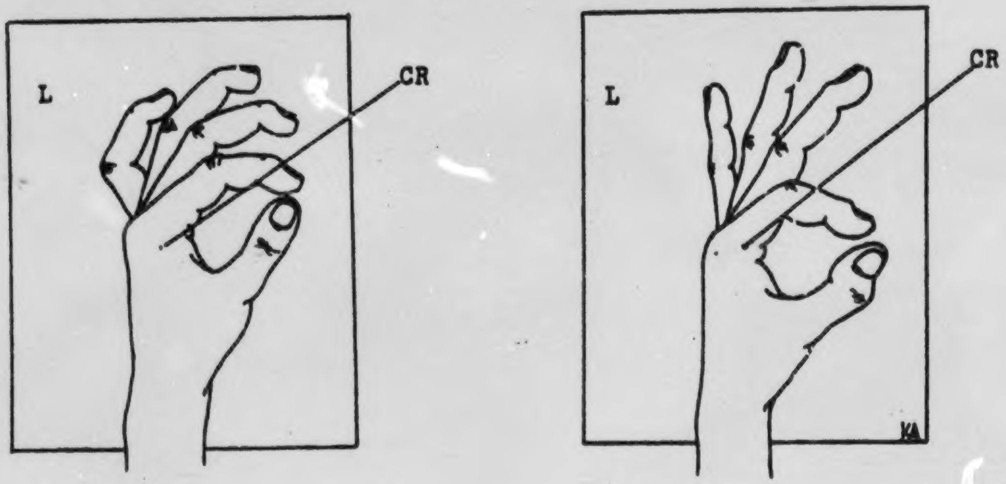
2) Lateral hand position demonstrates thumb in a PA position.

TM 8-280 pp. 10-10 Figure 10-5

Hand

Routine: PA and Oblique

Additional: Splayed



Hand Position Splayed

PFR: Head of second (2) metacarpal to center of film holder

Film Rundown: 8 x 10, L W, NB CR: VP Cone: FFC

Alignment: Part centered with hand vertical and fingers spread apart

Demonstrates: hand and lateral fingers

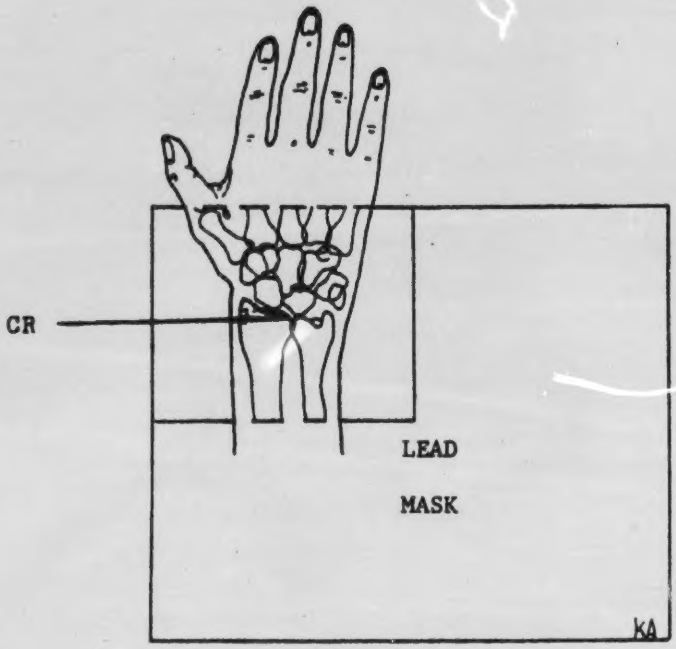
Notes: FFD 40" ID: Either lateral border

1. IMMOBILIZATION: Place sandbags against forearm and radiolucent material under thumb.
2. Remove artifacts; rings, watches, bracelets etc.

TM 8-280 pp 10-10 Figure 10-5

Wrist

Routine: PA, PA w/Ulna Flexion, Oblique and Lateral



Wrist **Position** PA

PFR: Midpoint of styloid processes to center of film

Film Rundown: 1 10 x 12 CW NB **CR:** VP **Cone:** FEC

Alignment: Part centered and styloids parallel to film.

Demonstrates: Wrist joint (eight) carpals, distal radius and ulna and proximal metacarpals.

Notes: **FFD:** 40" **ID:** Lateral border with lateral view.

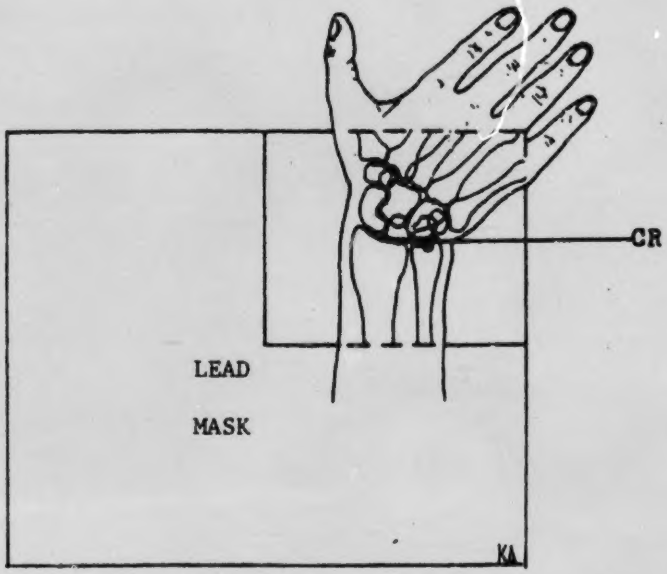
Immobilization: Place sandbags against mid-forearm. Remove all artifacts.

1) Patient may be instructed to clench fist losely to bring carpals in close contact with film

1194

Wrist

Routine: PA, PA w/Ulna Flexion, Oblique and Lateral



Wrist **Position** PA w/Ulna Flexion

PFR: Midpoint of styloid processes to center of film

Film Rundown: 1 10 x 12 CW NB **CR:** VP **Cone:** FFC

Alignment: Part centered, styloids parallel to film with hand flexed toward the ulna.

Demonstrates: Primarily: The Navicular bone. Secondarily: Same as PA.

Notes: **FFD:** 40" **ID:** Lateral border with lateral view.

1) Immobilization: Place sandbags against mid-forearm.

2) Flex hand off upper corner of cassette toward the lateral film border.

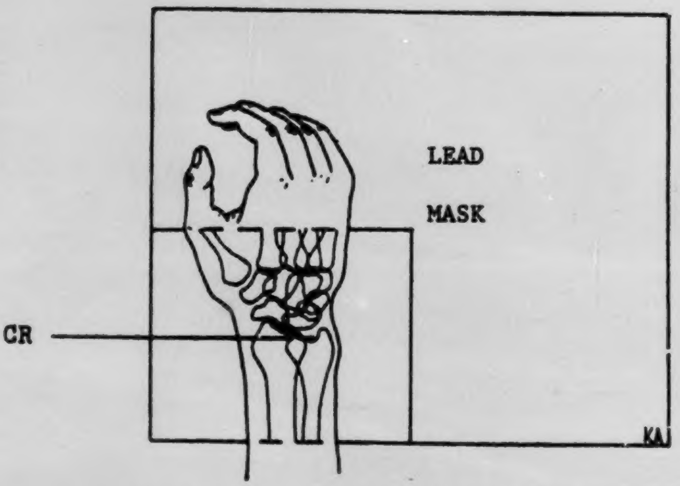
3) Radial flexion best demonstrates the Pisiform.

1195

TM 8-280 pp. 10-12 Figure 10-7

Wrist

Routine: PA, PA w/Ulna Flexion, Oblique and Lateral



Wrist Position Oblique

PFR: Midpoint of styloid processess to center of film

Film Rundown: 1 10 x 12 CW NB CR: VP Cone: FFC

Alignment: Part centered with plane through styloids and heads of metacarpals forming a 45° angle to the film.

Demonstrates: Same as PA demonstrated in an oblique position.

Notes: FFD: 40" ID: Lateral border with lateral view.

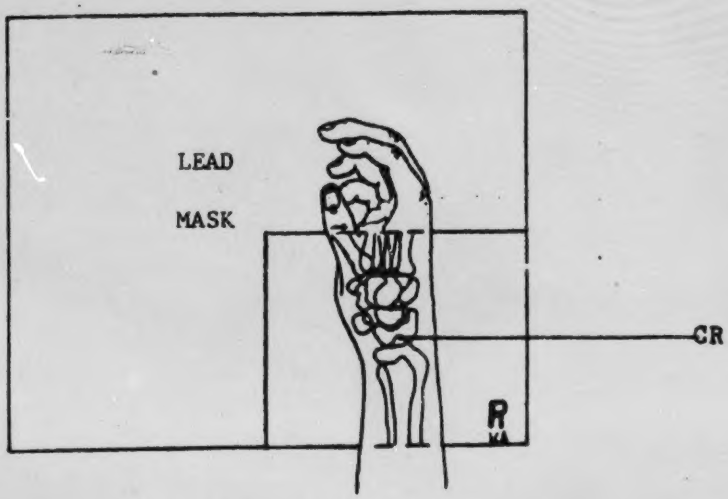
1) Immobilization: Place sandbags against mid-forearm

TM 8-280 pp. 10-13 Figure 10-8

1196

Wrist

Routine: PA, PA w/Ulna Flexion, Oblique and Lateral



Wrist **Position** Lateral

PFR Midpoint of styloid processess to center of film

Film Rundown: 1 10 x 12 CW NB CR: VP Cone: FFC

Alignment: Part centered, flex elbow 90° and supinate the wrist 5° to superimpose the styloids in a true lateral position

Demonstrates: Same as PA in lateral position.

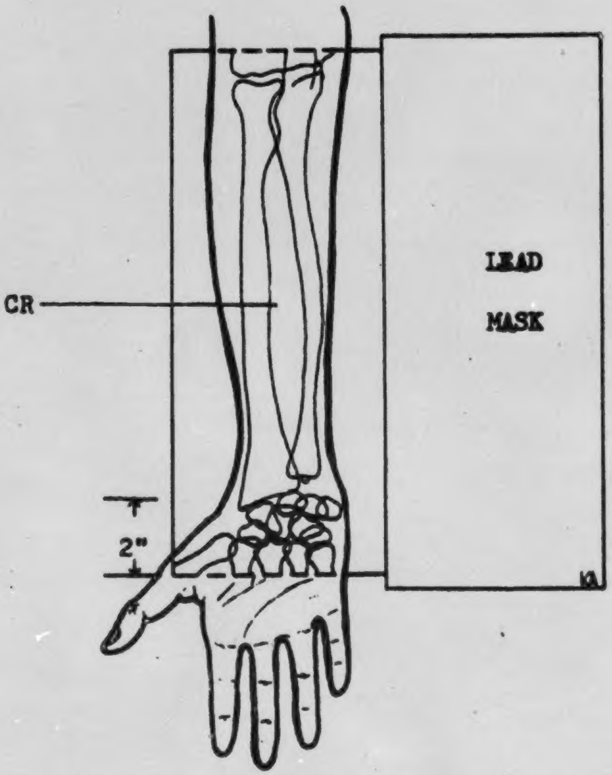
Notes: FFD: 40" ID: Lateral border with lateral view.

Immobilization: Place sandbags against mid-forearm.

1197

Forearm

Routine: Distal Forearm AP and Lateral



Distal Forearm Position AP

PFR: Styloid processess 2" above the lower border of film holder.

Film Rundown: 1 10 x 12 LW NB CR: VP Cone: FFC

Alignment: Part centered. Epi's and Styloids parallel as nearly as possible to film.

Demonstrates: Wrist joint and distal 2/3 of Radius and Ulna.

Notes: FFD: 40". ID: Either lateral border.

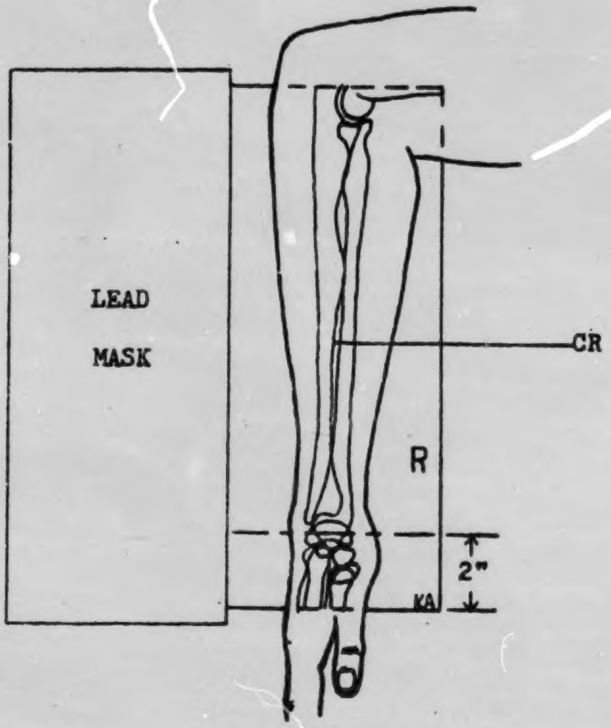
Immobilization: Place sandbags across extended fingers of hand.

1) All long bones must include one joint — the joint nearest the site of injury. 2) The length of the bone is placed to the length of the film. 3) Remove artifacts.

TM 8-280 pp. 10-15 FIGURE 10-10

Forearm

Routine: Distal Forearm AP and Lateral



Distal Forearm Position Lateral

PFR: Styloid processes 2" above the lower border of film holder

Film Rundown: 1 10 x 12 LW NB CR: VP Cone: FFC

Alignment: Part centered, elbow flexed 90° with Epi's and Styloids perpendicular as nearly as possible to the film.

Demonstrates: Wrist joint and distal 2/3 of Radius and Ulna

Notes: FFD: 40" ID: Either lateral border

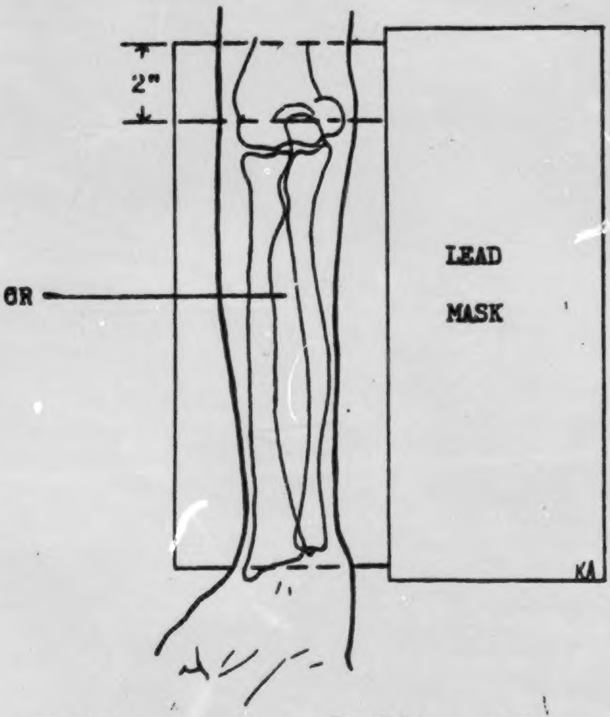
1. Immobilization: Place sandbags against sides of extended fingers.
2. This routine best demonstrates Colles' Fracture. Colle's Fracture: A fracture of the distal radius with posterior displacement of the distal fragments.
3. Remove Artifacts.

TM 8-280 pp. 10-16 Figure 10-11

1199

Forearm

Routine: Proximal Forearm AP and Lateral



Proximal Forearm Position AP

PFR: Epicondylas 2" below the upper border of film holder

Film Rundown: 1 10 x 12 LW NB CR: VP Cone: FFC

Alignment: Part centered. Epi's and Styloids parallel as nearly as possible to the film.

Demonstrates: Elbow joint and proximal 2/3 of Radius and Ulna

Notes: FFD 40" ID: Either lateral border

Immobilization: Place sandbag in palm of hand.

1) Shoulder should be at the level of the table top.

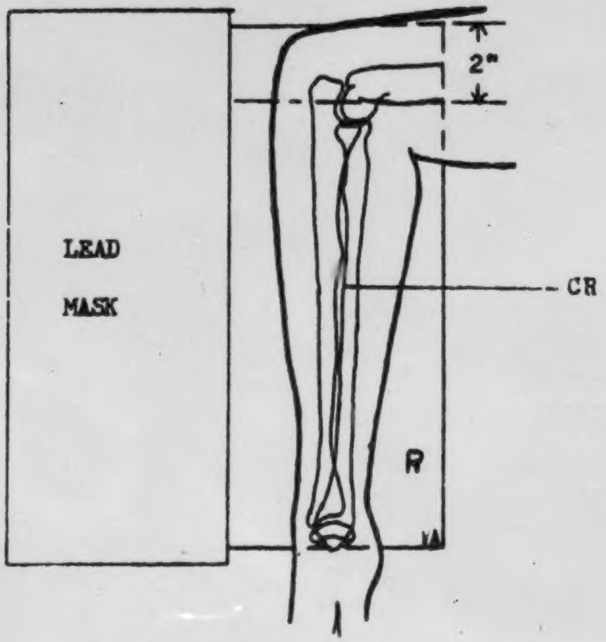
2. Remove artifacts.

TM 8-280 pp.10-15 Figure 10-10

1200

Forearm

Routine: Proximal Forearm AP and Lateral



Proximal Forearm Position Lateral

PFR: Epicondyles 2" below the upper border of film holder

Film Rundown: 1 10 x 12 LW NB CR: VP Cone: FEC

Alignment: Part centered, elbow flexed 90° with Epi's and Styloids perpendicular as nearly as possible to the film.

Demonstrates: Elbow joint and proximal 2/3 of Radius and Ulna

Notes: FFD: 40" ID: Either lateral border

Immobilization: Place sandbags against sides of extended fingers.

1. Remove artifacts.

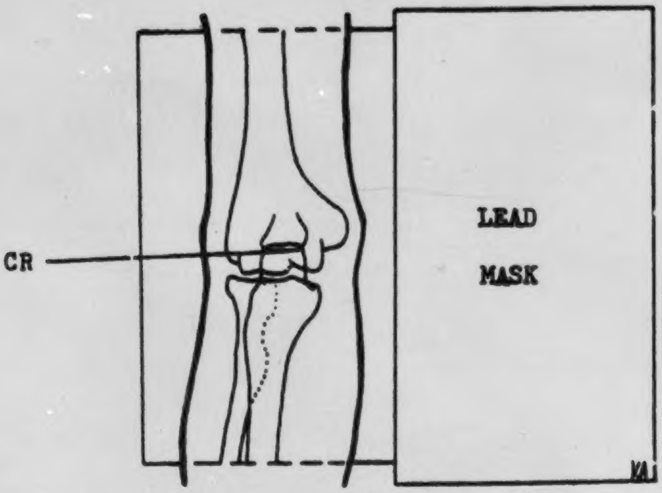
1201

TM 8-280 pp. 10-16 Figure 10-11

Elbow

Routine: AP and Lateral

Additional: Jones



Elbow Position AP

PFR: Midpoint of Epicondyles to center of film

Film Rundown: 1 10 x 12 LW NB CR: VP Cone: FFC

Alignment: Part centered with Epicondyles parallel to the film.

Demonstrates: Elbow joint, proximal Radius and Ulna and distal Humerus.

Notes: FFD: 40" ID: Either lateral border.

Immobilization: Place sandbag in palm of hand.

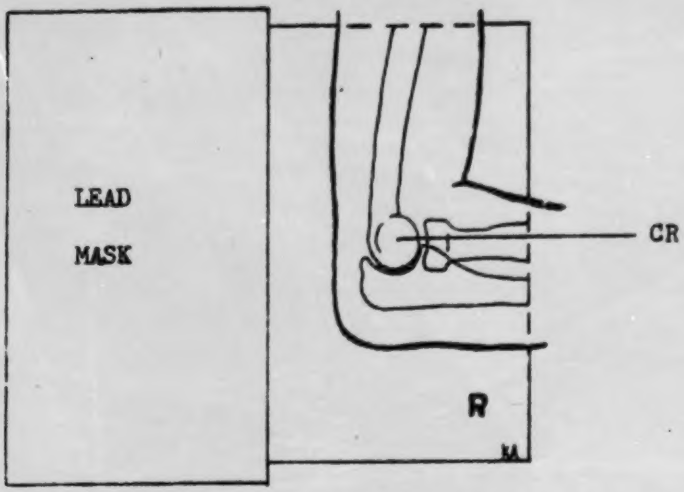
1) Shoulder should be at the level of the table top.

TM 8-230 pp. 10-17 Figure 10-12

Elbow

Routine: AP and Lateral

Additional: Jones



Elbow Position Lateral

PFR: Midpoint of Epicondyles to center of film

Film Rundown: 1 10 x 12 CW NB CR: VP Cone: FFC

Alignment: Part centered, forearm flexed 90° with epicondyles and styloids perpendicular to the film.

Demonstrates: Elbow joint, proximal Radius and Ulna and distal Humerus.

Notes: FFD: 40" ID: Either lateral border.

Immobilisation: Place sandbags against forearm on both sides.

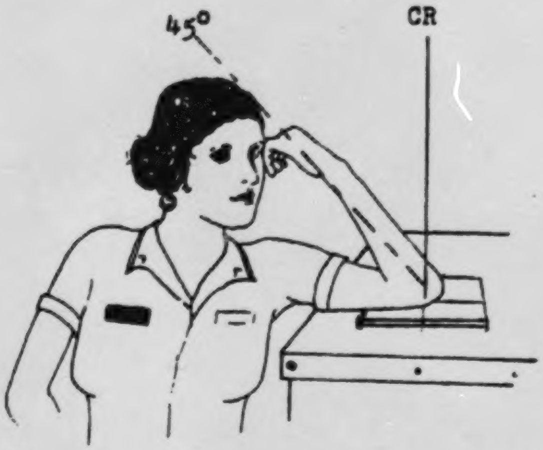
1) Humerus enters from the upper film border and forearm extends off the lateral film border.

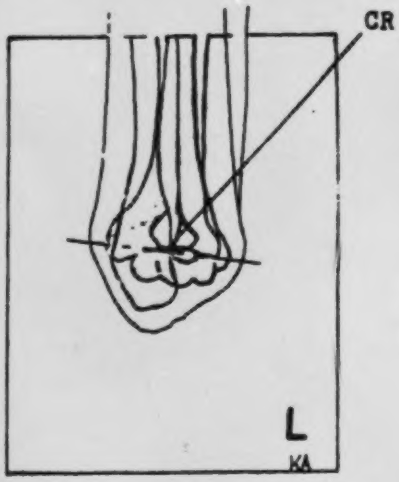
TM 8-290 10-18 Figure 10-13

Elbow

Routine: AP and Lateral

Additional: Jones





Elbow Position Jones

PFR: Midpoint of epicondyles to center of film.

Film Rundown: 1 8 x 10 LW NB CR: VP Cone: FFC

Alignment: Part centered with Epicondyles parallel to the film. Humerus and forearm hyperflexed forming a 45° angle. Palm facing down.

Demonstrates: Olecranon process and distal Humerus.

Notes: FFD: 40" ID: Either lateral border.

Immobilisation: Have patient hold hand of affected extremity with other hand.

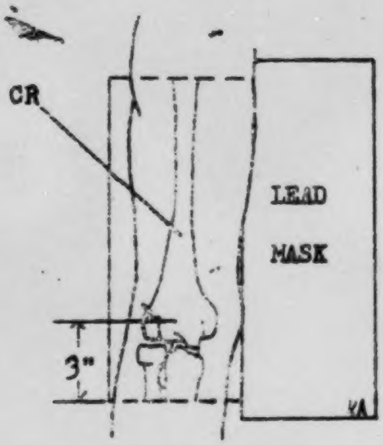
1) Jones and lateral views of Elbow best demonstrate the Olecranon process.

TM 8-280 pp. 10-18 Figure 10-13

1204

Humerus

Routine: Distal Humerus AP and Lateral



Distal Humerus Position AP

PFR: Epicondyles 3" above lower border of film holder

Film Rundown: 1 10 x 12 LW NB CR: VP Cone: FEC

Alignment: Part centered and Epicondyles parallel to film.

Demonstrates: Distal 2/3 of Humerus and Elbow joint.

Notes: FFD: 40" ID: Either lateral border.

Immobilization: Place sandbags against forearm.

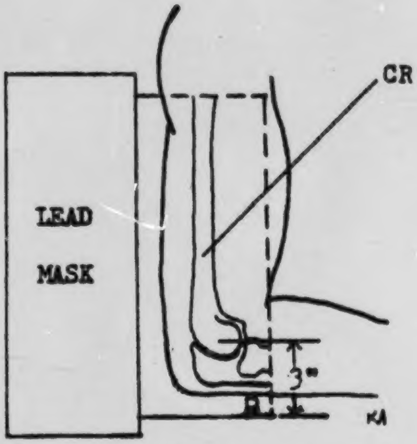
1) Shoulder should be at same level as table top.

1205

TM 8-280 pp. 10-21 Figure 10-16

Humerus

Routine: Distal Humerus AP and Lateral



Distal Humerus Position Lateral

PFR: Epicondyles 3" above lower border of film holder

Film Rundown: 1 10 x 12 LW NB CR: VP Cone: FFC

Alignment: Part centered and elbow flwxed 90° with epicondyles perpendicular and styloids as nearly perpendicular as possible to film.

Demonstrates: Distal 2/3 of Humerus and Elbow joint.

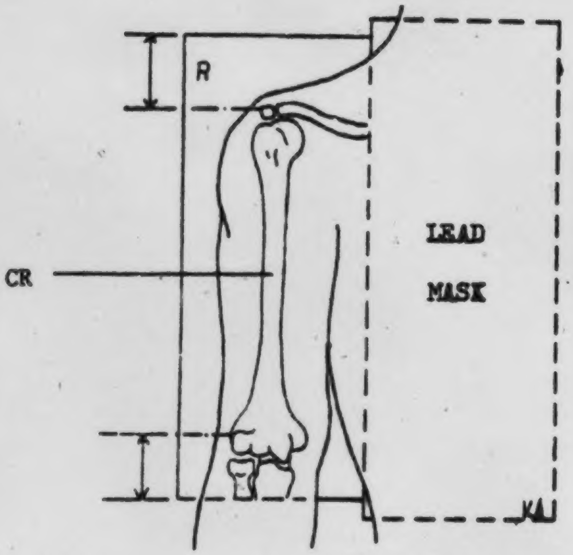
Notes: FFD: 40" ID: Either Lateral border.

Immobilization: Place sandbags against forearm

1) Humerus enters from the upper film border and forearm extends off the lateral film border.

Humerus

Routine: Full Length Humerus AP with External Rotation (palm up)
AP with Internal Rotation (palm out)



Full Length Humerus Position AP w/ External Rotation (palm up)

PFR: Epicondyles are to the lower film border as the acromion process is to the upper film border.

Film Rundown: 1 14 x 17 LW NB CR: VP Cone: FEC

Alignment: Part centored with Epicondyles parallel to film

Breathing Technique: Suspended Respiration

Demonstrates: Full Length Humerus in AP position

Notes: FFD: 40" ID: Either lateral border

Immobilisation: Place sandbag in palm of hand.

1) External Rotation the Greater Tuberosity is demonstrated on lateral aspect of Humeral head.

2) Cathode reference - Cephalic.

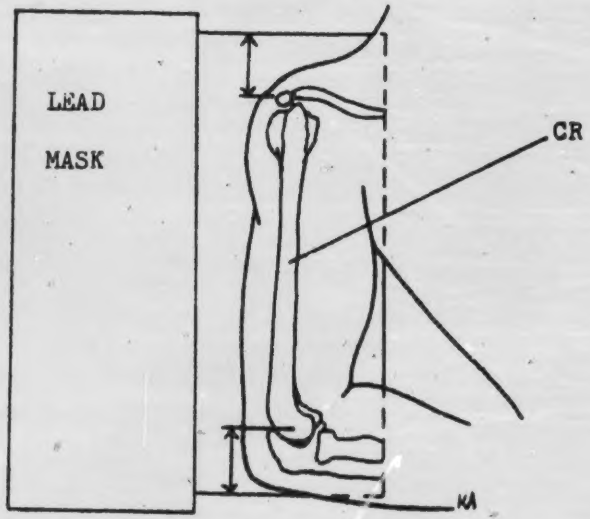
TM 8-280 pp. 10-21 Figure 10-16

1207

Humerus

Routine: Full Length Humerus AP with External Rotation (Palm Up)

AP with Internal Rotation (Palm Out)



Full Length Humerus **Position** AP with Internal Rotation (Palm Out)

PFR: Epicondyles are to the lower film border as the Acromion Process is to the upper film border.

Film Rundown: 14 x 17, LW, NB **CR:** VP **Cone:** FFC

Alignment: Part centered with Epicondyles perpendicular to film

Breathing Technique: Suspended Respiration

Demonstrates: Full length humerus in lateral position

Notes: FFD: 40" **ID:** Either lateral border

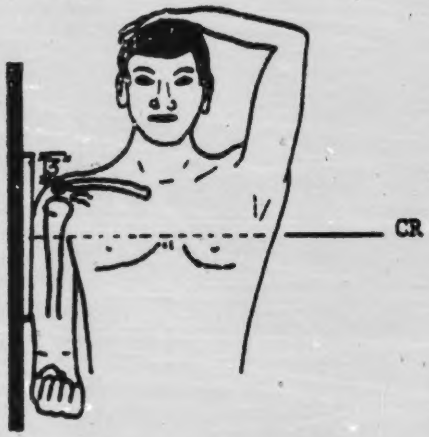
1. IMMOBILIZATION: Place sandbag against turned out palm
2. Internal rotation, the Greater Tuberosity is superimposed over the humeral head.
3. Cathode Reference: Cephalic

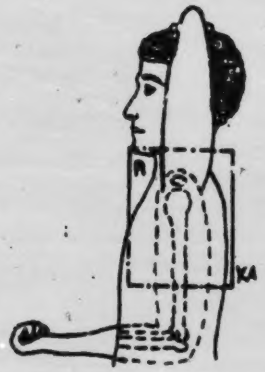
TM 8-280 pp. 10-22 Figure 10-17

1208

Humerus

Additional Position: Trans-thoracic





PFR: Acromion Process 3" below upper border of film holder

Film Rundown: 10x12, LW, B CR: HP Cone: FFC

Alignment: Part centered, Epicondyles and styloids perpendicular to film

Breathing Technique: Suspended Inspiration

Demonstrates: Head, neck and upper 2/3 of humerus

Notes: FFD: 40" ID: Either lateral border

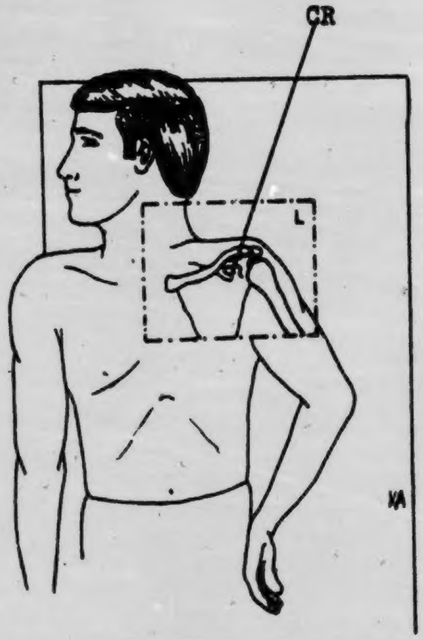
1. When possible, the forearm of the affected side should be raised and positioned parallel to the floor, palm up and epicondyles perpendicular to the film. 2. Suspended inspiration for short scale of contrast. 3. May be refered to as Lawrence Position 4. Patient Dress: Clothing from waist up removed and placed in a gown.

TM 8-280 pp. 10-24 Figure 10-19

1209

Shoulder

Routine: AP Shoulder w/ Internal Rotation (palm out) and External Rotation (palm up)



AP Shoulder w/ Position Internal Rotation

PFR: Coracoid Process to center of film

Film Rundown: 1 10 x 12 CW B CR: VP Cone: FFC

Alignment: Part centered and Epicondyles perpendicular to table

Breathing Technique: Suspended Expiration (to obtain uniform density)

Demonstrates: Shoulder joint with Greater Tuberosity superimposed over the Humeral head.

Notes: FFD: 40" ID: Above the part reading down.

Immobilization: Place sandbag against turned out palm.

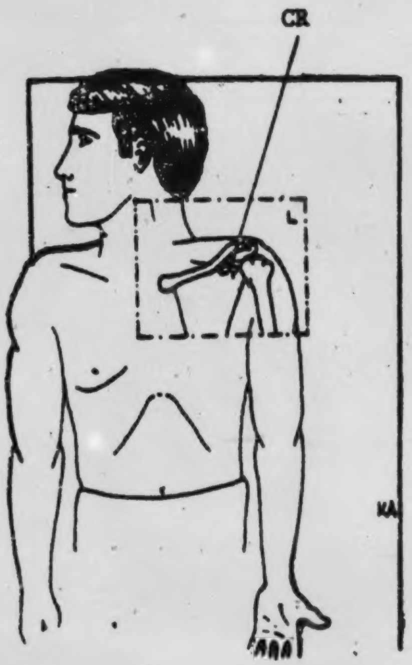
1) Patient dress should be dressing gown to assure artifact free film and to afford patient privacy during examination.

TM 8-280 pp. 10-25 Figure 10-20

1210

Shoulder

Routine: AP Shoulder w/ Internal Rotation (palm out) and External Rotation (palm up)



AP Shoulder Position External Rotation (palm up)

PFR: Coracoid Process to center of film

Film Rundown: 1 10 x 12 CW B CR: VP Cone: FFC

Alignment: Part centered and Epicondyles parallel with the table

Breathing Technique: Suspended Expiration

Demonstrates: Shoulder joint with the Greater Tuberosity on the lateral aspect of the Humeral head.

Notes: FFD: 40" ID: Above the part reading down.

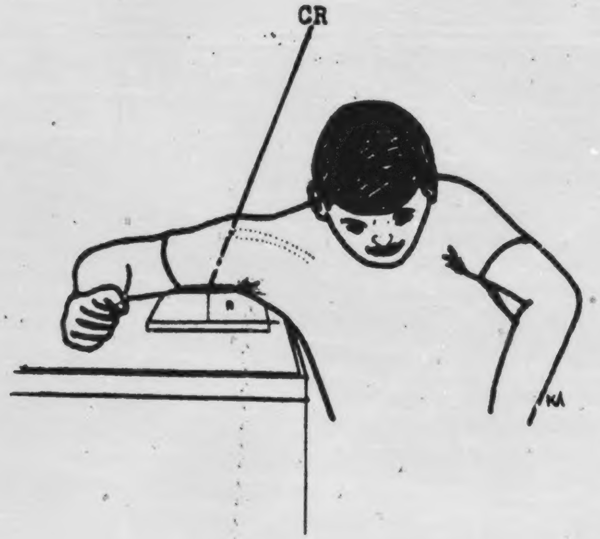
Immobilization: Place sandbag in open palm.

1) Patient dress same as Internal Rotation view.

TM 8-280 pp. 10-25 Figure 10-20

1211

Superior-Inferior Shoulder Joint, Head and Neck of Humerus



PFR: Acromion process to the center of the film.

Film Rundown: 8x10, CW, NB CR: 15° toward elbow Cone: FFC

Alignment: Epicondyles perpendicular, arm and forearm form a 90° angle.

Breathing Technique: Suspended respiration

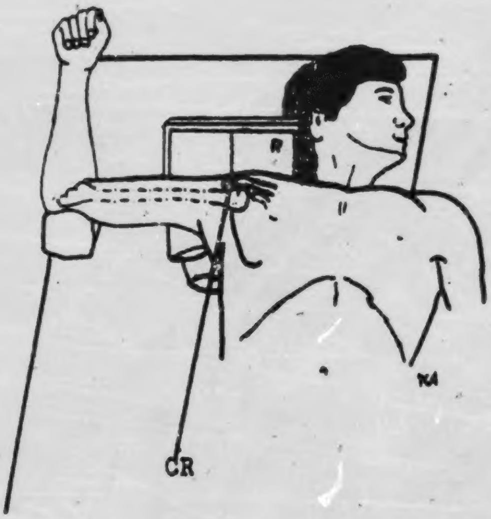
Demonstrates: Head of humerus and glenoid fossa

Notes: FFD: 40" ID: Above part

1. IMMOBILIZATION: Place sand bags against both sides of the forearm.
2. The patient should be in a dressing gown for this procedure. Undergarments removed from shoulder to waist. Necklace removed etc.
3. Patient's ability to abduct arm to a near right angle should be verified before this position is undertaken.
4. TM 8-280 explains this position can be taken with a VP CR. Both methods are acceptable.

TM 8-280 pp. 10-23 Figure 10-18

Additional view: Inferior-Superior Shoulder Joint, Head and Neck of Humerus



PFR: Acromion process to the center of the film

Film Rundown: 8x10, LW, NB CR: HP & 20° medially Cone: FFC

Alignment: Part centered, Epicondyles parallel to the table top.

Breathing Technique: Suspended respiration

Demonstrates: Inferosuperior projection of the glenohumeral joint, Lateral portion of coracoid process and the acromioclavicular articulation.

Notes: FFD: 40" ID: Above part

1. IMMOBILIZATION: Place sponge cushion under patient's shoulder and elbow to raise part to center of the film.. Sand bags placed on both sides of the forearm.

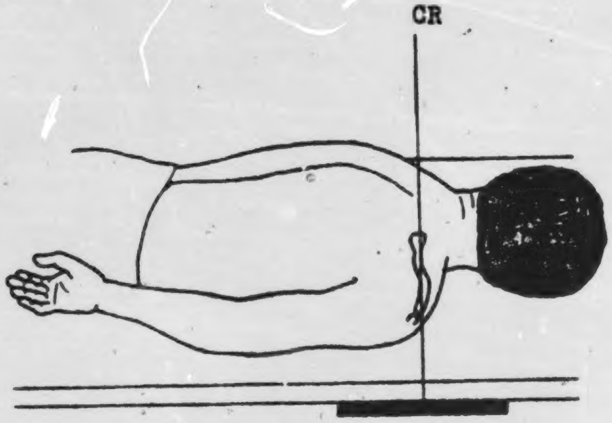
2. This view is ideal when patient is in an aeroplane splint or abduction cast.

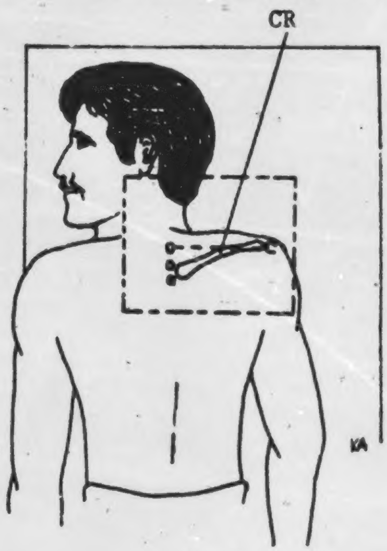
3. Patient dress is the same as for superior-inferior view.

Clavicle

Routine: PA Right and Left (Bi - lateral)

Additional:





Clavicle Position PA

PFR: Midpoint of Clavicle to center of film

Film Rundown: 1 10 x 12 CWB CR: VP Cone: FFC

Alignment: Midpoint between Acromion Process and spinous processes of the vertebral column over the centerline of the table.

Breathing Technique: Suspended Expiration (to obtain uniform density)

Demonstrates: Clavicle

Notes: FFD: 40" ID: Above part reading down.

Immobilization: Palm of hand facing up and sandbag placed in open palm.

1) Patient dress should be dressing gown to assure artifact free film.

2) Turn head away from affected side.

3) Bi - lateral views are required for comparison.

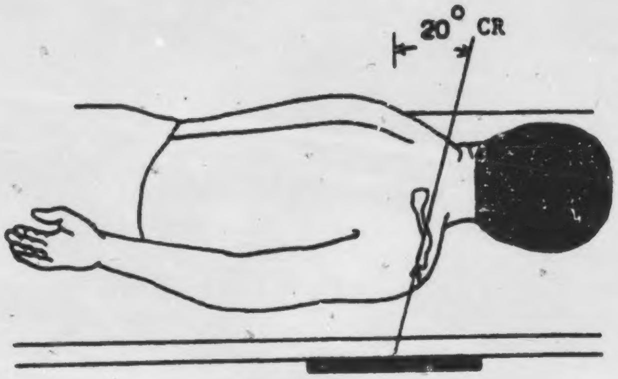
TM 9-280 pp. 10-28 Figure 10-23

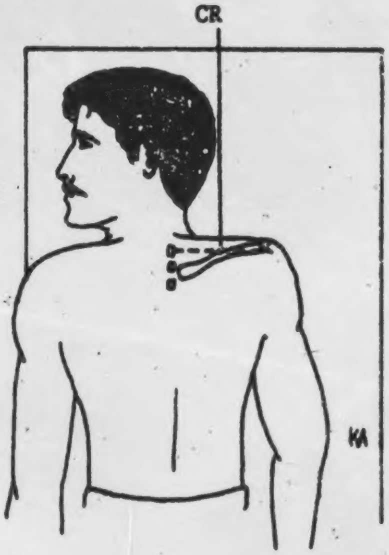
1214

Clavicle

Routine: PA right and left (Bilateral)

Additional: Tangential





Clavicle Position Tangential

CRPR: Midpoint of clavicle projected to center of film holder

Film Rundown: 10 x 12, CW, B CR: 20° Caudad Cone: FFC

Alignment: Midpoint between Acromion Process and vertebral column over center line of table

Breathing Technique: Suspended Expiration

Demonstrates: Clavicle, to show displacement

Notes: FFD: 40 " ID: Above part reading down

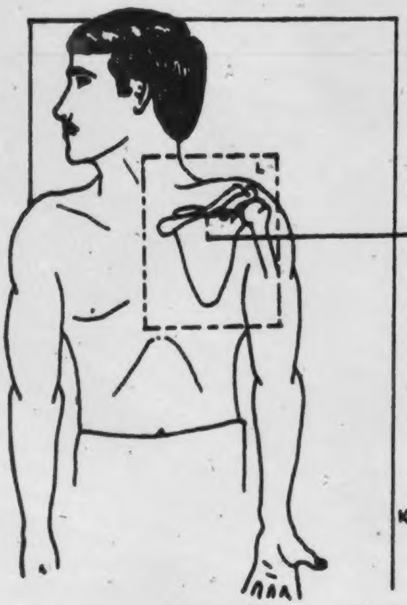
Same as PA

1215

1215

Scapula

Routine: AP and Lateral



Scapula Position AP

PFR: A point 2" medial and 2" inferior from the Coracoid Process to center of film.

Film Rundown: 1 10 x 12 IDGR: VP Cone: FFC

Alignment: Patient supine, Epicondyles parallel to table (palm up).

Breathing Technique: Suspended Expiration (to obtain uniform density)

Demonstrates: Saapula

Notes: FFD: 40" ID: Above part reading down.

Immobilisation: Place sandbag in open palm.

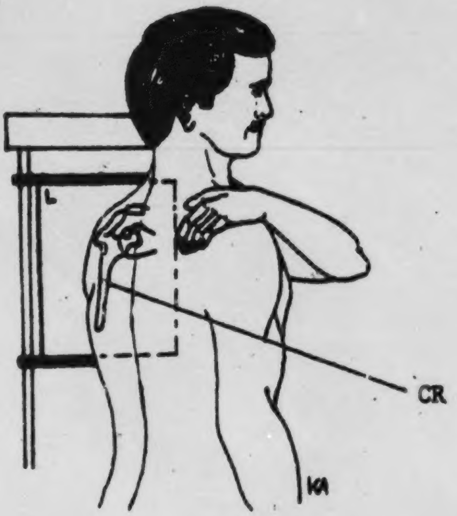
1) Patient dress should be dressing gown to assure artifact free film.

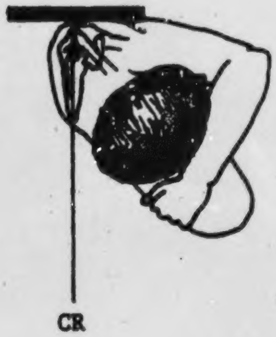
TM 8-280 pp. 10-26 Figure 10-21

1216

Scapula

Routine: AP and Lateral





Scapula Position Lateral

PFR: Midpoint of vertebral border to center of film.

Film Rundown: 1 10 x 12 IWB CR: HP Cone: FFC

Alignment: Acromion Process and midpoint of vertebral border are in the same vertical plane, and over the center of film.

Breathing Technique: Suspended Respiration.

Demonstrates: Scapula

Notes: FFD: 40" ID: Upper film border, reading down.

Immobilization: The hand of the affected side is placed on the opposite shoulder and suspended respiration is used.

1) Patient dress same as for AP view.

TM 8-280 pp. 10-22 Figure 10-22

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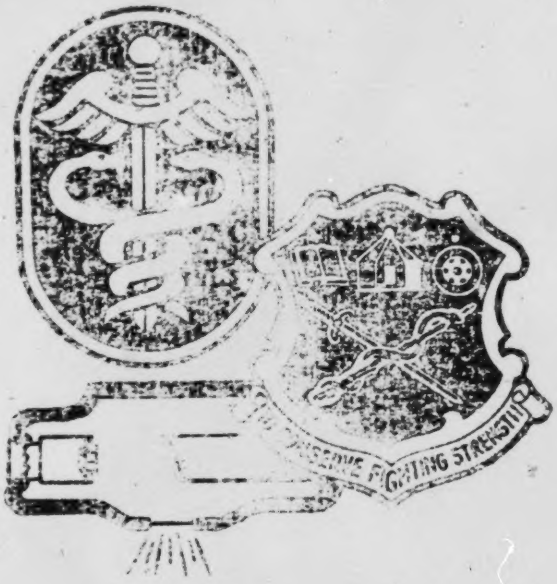
SFC J. BINKLEY
SFC R. GORDON

*GR 38-520-027-1A
047

X-RAY BRANCH



313-91P20

RADIOGRAPHIC POSITIONING
VOLUME II
LOWER EXTREMITY

MEDICINE AND SURGERY DIVISION
X-RAY BRANCH
FORT SAM HOUSTON, TEXAS 78234

*This general reference supersedes GR 38-520-027-1, 116

TABLE OF CONTENTS

LOWER EXTREMITY

PAGE

Objectives 2
Positioning of the Foot - Dorsal Plantar 3
Positioning of the Foot - Oblique 4
Positioning of the Foot - Lateral 5
Positioning of the Os Calcis - Inferior Superior (IS) 6
Positioning of the Os Calcis - Lateral 7
Positioning of the Ankle - Anterior Posterior 8
Positioning of the Ankle - Oblique 9
Positioning of the Ankle - Lateral 10
Positioning of the Leg - Anterior Posterior & Lateral (Distal) 11
Positioning of the Leg - Anterior Posterior & Lateral (Proximal) 12
Positioning of the Knee - Anterior Posterior 13
Positioning of the Knee - Lateral 14
Positioning of the Knee - Posterior Anterior 15
Positioning of the Knee - Holmblad 16
Positioning of the Knee - Beclere 17
Positioning of the Knee - Settegast - Supine position 18
Positioning of the Knee - Settegast - Prone position 19
Positioning of the Femur - Anterior Posterior (Distal) 20
Positioning of the Femur - Lateral (Distal) 21
Positioning of the Femur - Anterior Posterior (Proximal) 22
Positioning of the Femur - Lateral (Proximal) 23
Positioning of the Pelvis - Anterior Posterior 24
Positioning of the Pelvis - Anterior Posterior (Spread) 25
Positioning of the Hip - Anterior Posterior 26
Positioning of the Hip - Lateral 27
Positioning of the Sacrum - Anterior Posterior 28
Positioning of the Sacrum - Lateral 29
Positioning of the Coccyx - Anterior Posterior 30
Positioning of the Coccyx - Lateral 31

1219

OBJECTIVES

1. Identify by name the position and anatomical structures demonstrated.

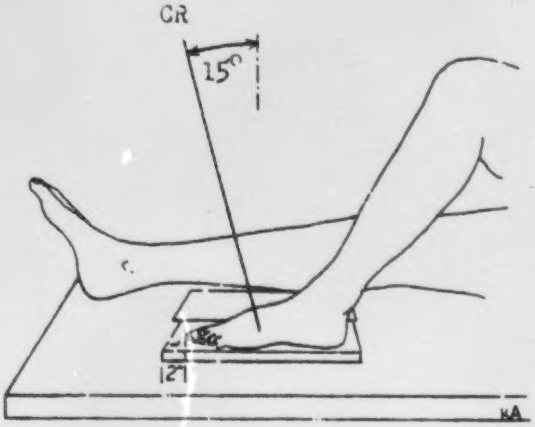
2. Determine the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization film identification and captioning necessary to demonstrate the position.

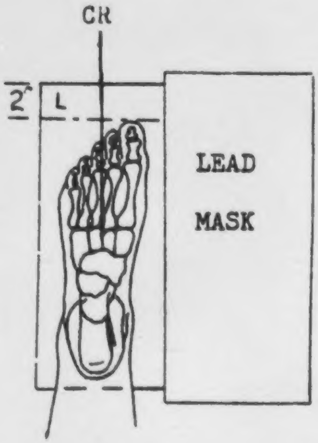
3. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiographic position.

Foot

Routine: Dorso-Plantar and Oblique

Additional: Lateral





Foot Position Dorso-Plantar

PFR: Great Toe 2" below the upper film border

Film Rundown: 10 x 12, LW, NB CR: 15° Cephalic Cone: FFC

Alignment: Part centered with sole of foot firmly in contact with film holder.

Demonstrates: Distal Tarsals, Metatarsals and Phalanges

Notes: FFD: 40" ID: Above digits reading down

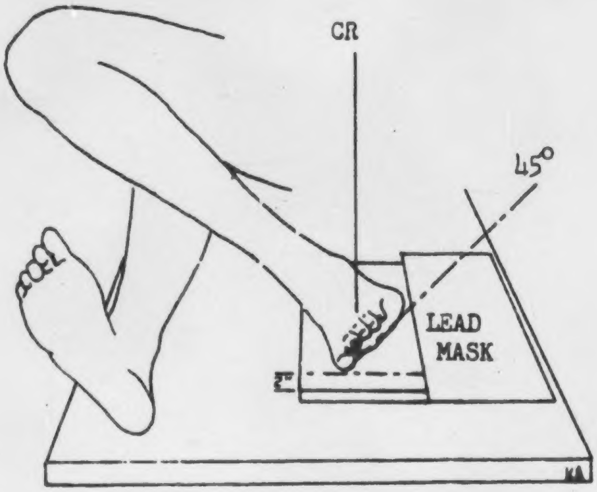
1. IMMOBILIZATION: Patient may hold knee to aid in immobilization.
2. The shoe and sock are removed.
3. A drape sheet is used if necessary.
4. Emphasize that the foot routine demonstrates the March Fracture.

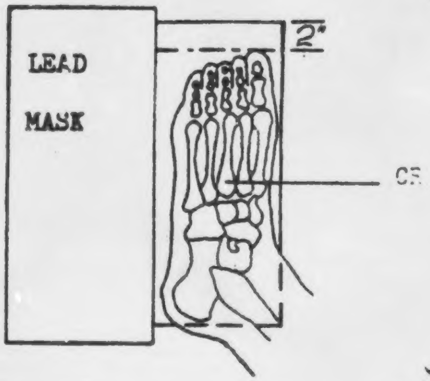
TM 8-280 pp. 10-30 Figure 10-25

Foot

Routine: Dorso-Plantar and Oblique

Additional: Lateral





Foot Position Oblique

PFR: Great Toe 2" below upper film border

Film Rundown: 10 x 12, 1W, NB CR: V.P. Cone: FFC

Alignment: Part centered. Foot and leg rotated medially until the Plantar surface of the foot is 45° to the surface of the film.

Demonstrates: Tarsals, Metatarsals and Phalanges

Notes: FFD: 40" ID: Above digits reading down

1. IMMOBILIZATION: Place sand bag beneath leg or support the knee of the side under study with the opposite knee and have the patient grasp the edge of the table.

2. Oblique View: Have the leg extend off lateral border of the film holder.

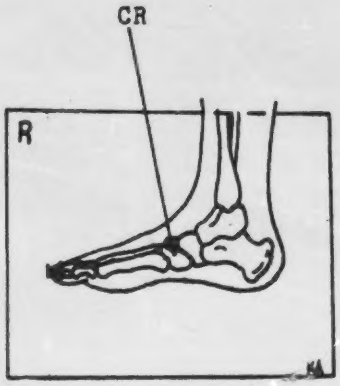
TM 8-280 pp. 10-31 Figure 10-36

1222

Foot

Routine: Dorso-Plantar and Oblique

Additional: Lateral



Foot Position Lateral

PFR: Transverse plane through the midlongitudinal arch to the center of the film holder

Film Rundown: 10 x 12, LW, NB CR: VP Cone: FFC

Alignment: Part centered and plantar surface of the foot perpendicular to the film holder.

Demonstrates: Foreign body localization or placement of fragments in fractures.

Notes: FFD: 40" ID: Above part reading down.

1. IMMOBILIZATION: Place sand bag across leg.

2. VARIATION: Weight bearing laterals of both feet may also be taken to determine the condition of the longitudinal arch. Patient is standing with the weight of the body equally distributed on both feet. CR is HP.

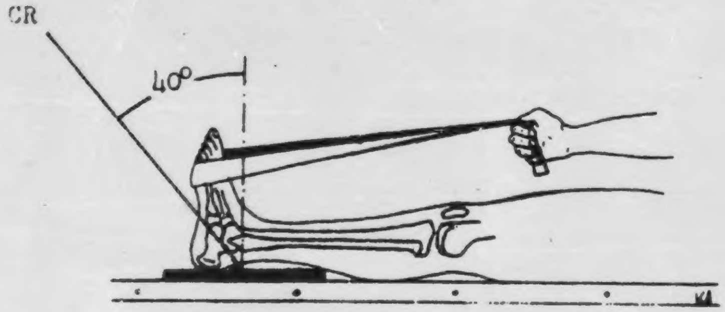
3. Shoes and socks removed.

1223

TM 8-280 pp. 10-32 Figure 10-27

Os Calcis

Routine: Infero-Superior and Lateral



Os Calcis Position Infero-Superior

PFR: Midmalleolar plane to center of the film holder

Film Rundown: 10 x 12, CW, NB CR: 40° Ceph Cone: FFC

Alignment: Part centered with epicondyles parellel to table and plantar surface of the foot perpendicular to the film holder.

Demonstrates: Os Calcis, Malleoli and soft tissues

Notes: FFD: 40" ID: On the lateral border or below the lateral view.

1. IMMOBILIZATION: Use belt-type traction on foot.

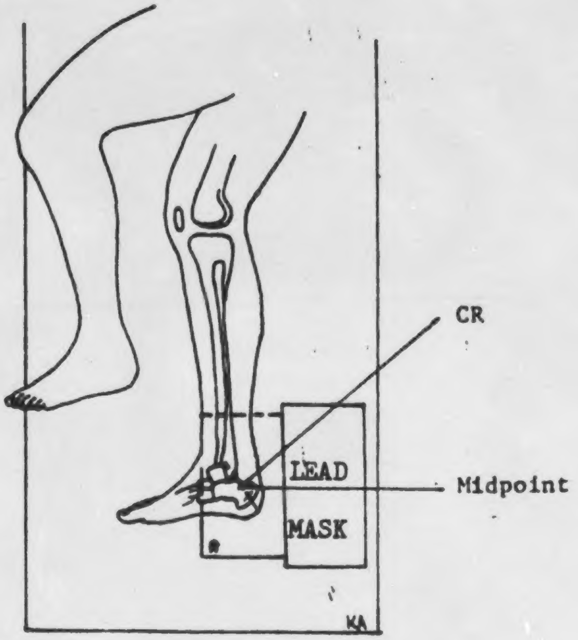
2. Patient is instructed to pull belt-type traction till plantar surface of the foot is perpendicular to the film.

3. Shoe and sock are removed.

M 8-280 pp. 10-36 Figure 10-31

Os Calcis

Routine: Infero-Superior and Lateral



Os Calcis Position Lateral .

PFR: Midpoint of a line between the medial malleolus and the apex of the heel to the center of the film holder.

Film Rundown: 10 x 12, CW, NB CR: VP Cone: FEC

Alignment: Part centered, Epicondyles perpendicular to the table, foot and leg form a 90° angle.

Demonstrates: Os Calcis

Notes: FFD· 40" ID: On the lateral border or below the lateral view.

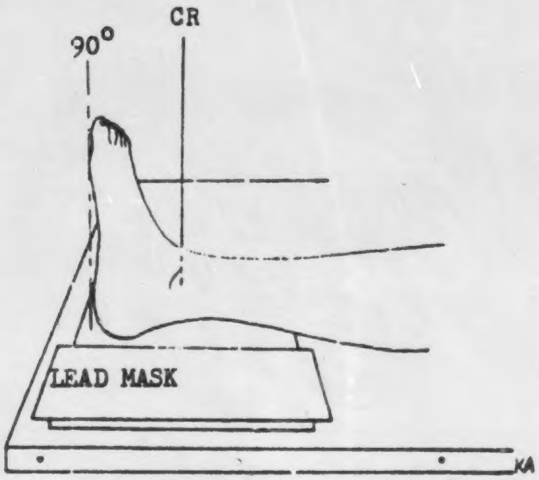
1. IMMOBILIZATION: Place sand bag against toes.

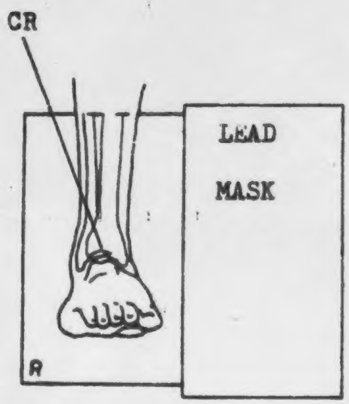
2. Lateral view is done first. Foot must extend off the lateral border of the film holder.

1225

Ankle

Routine: AP, Oblique and Lateral





Ankle Position AP

PFR: Midpoint between malleoli to center of film holder

Film Rundown: 10 x 12, CW, NB CR: VP Cone: FFC

Alignment: Part centered and epicondyles parallel to the table

Demonstrates: Talus, Distal Tibia and Fibula and Ankle joint

Notes: FFD: 40" ID: Either lateral border

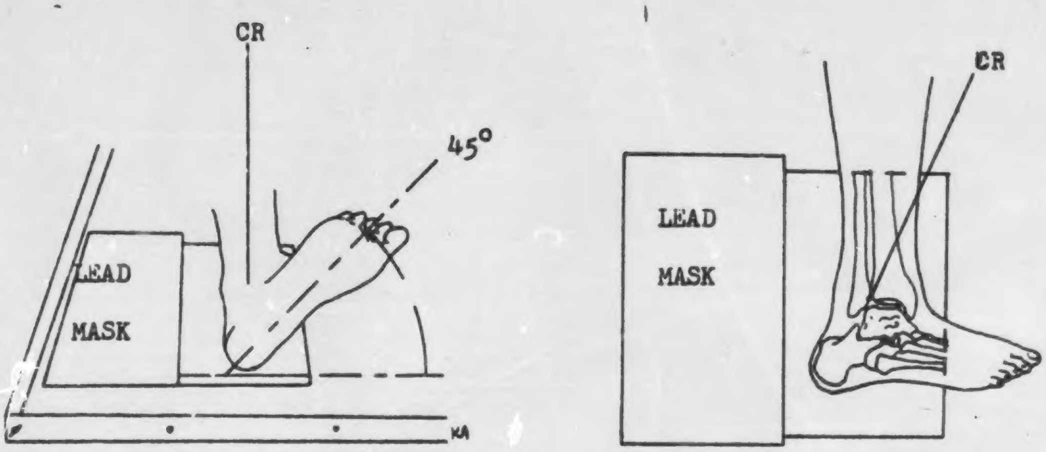
1. IMMOBILIZATION: Place sand bag against sole of foot.
2. Plantar surface of the foot perpendicular to the film.
3. Shoes and socks are removed.

1226

TM 8-280 pp. 10-33 Figure 10-28

Ankle

Routine: AP, Oblique and Lateral



Ankle Position Oblique

PFR: Midpoint between malleoli to the center of the film holder

Film Rundown: 10 x 12, CW, NB CR: VP Cone: FFC

Alighment: Part centered with the foot and leg rotated 45° medially

Demonstrutes: Distal Tibiofibular articulation, lateral malleolus and ankle joint

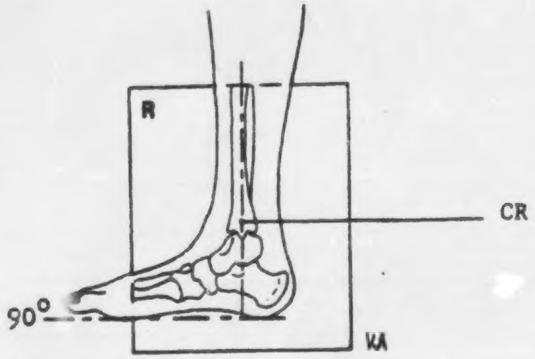
Notes: FFD: 40" LD: Either lateral border

1. IMMOBILIZATION: Rest toes against sand bag
2. Plantar surface of the foot perpendicular to the film.
3. Take oblique first. Foot extends off the lateral film border with toes resting on a sand bag.

TM 8-280 pp. 10-34 Figure 10-29

Ankle

Routine: AP, Oblique and Lateral



Ankle Position Lateral

PFR: Malleolar plane (Medial Malleolus) to the center of the film

Film Rundown: 8 x 10, LW, NB CR: VP Cone: FFC

Alignment: Part centered. Epicondyles perpendicular to the table. Foot and leg form a 90° angle.

Demonstrates: Distal Tibia and Fibula, Talotibial articulation and Tarsals.

Notes: FFD: 40" ID: Either lateral border

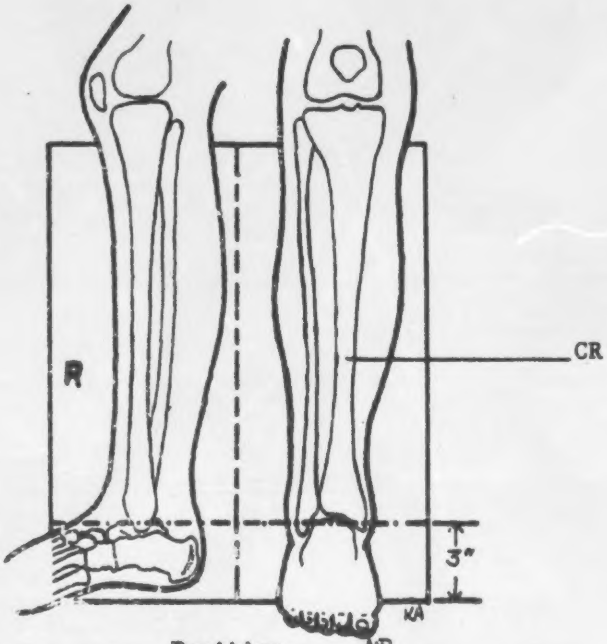
1. IMMOBILIZATION: Place sand bag against toes.

2. For lateral views of the lower extremity, patient is always laterally recumbant with the lateral side of the effected extremity next to the film.

TM 8-280 pp. 10-35 Figure 10-30

Leg

Routine: AP and Lateral Distal Leg



Position Lateral , Position AP

PFR: Malleoli 3" above the lower film border

Film Rundown: 14 x 17, LW, NB CR: VP Cone: FFC

Alignment: Part centered. (AP) Epicondyles parallel to the film. ,
(Lateral) Epicondyles perpendicular to the film.

Demonstrates: Ankle joint and lower 2/3 of the Tibia and Fibula. ,

Notes: FFD: 40" ID: Either lateral border

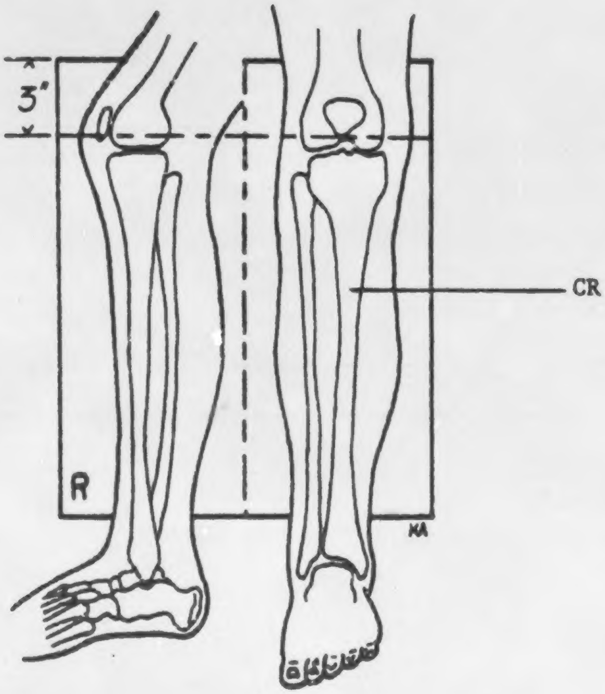
1. IMMOBILIZATION: Place sandbag against toes and the plantar surface of the foot.
2. Shoe and sock are removed. Use drape sheet if necessary.
3. The lateral view extends off the lateral border of the film border.
4. The distal leg routine best demonstrates Potts Fracture.

TM 8-280 pp. 10 37-38 Figure 10 32 & 33

1229

Leg

Routine: AP and Lateral Proximal Leg



Position Lateral

Position AP

PFR: Apex of the Patella 3" below the upper film border.

Film rundown: 14 x 17, LW, NB CR: VP Cone: FFC

Alignment: Part Centered. (AP) Epicondyles parallel to the film

(Lateral) Epicondyles perpendicular to the film.

Demonstrates : Knee joint and the proximal 2/3 of the Tibia and Fibula.

Notes: FFD 40" ID: Either lateral border

1. IMMOBILIZATION: Place sandbag against the toes and plantar surface of the foot.
2. The shoe and sock are removed. Use drape sheet if necessary
3. Lateral view extends off the lateral border of the film holder.

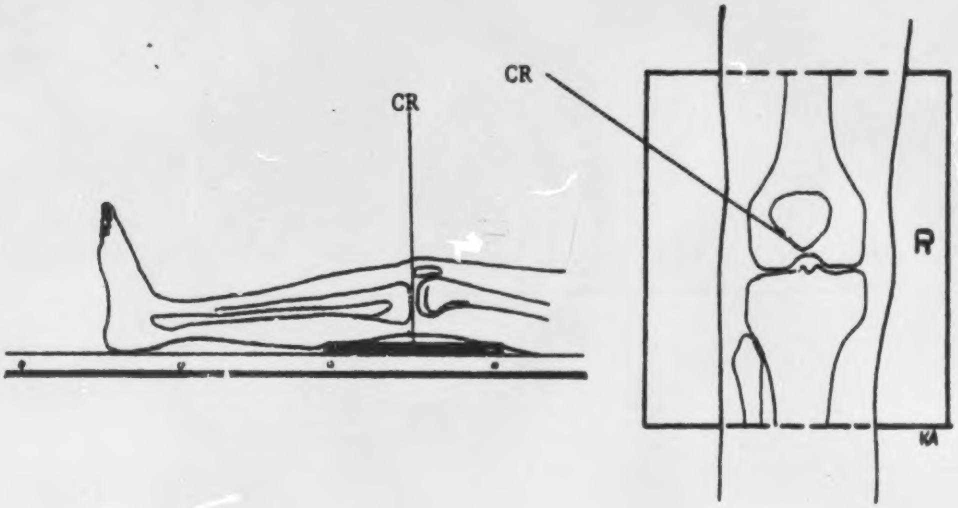
TM 8-280 pp. 10 37 & 38 Figure 10 32 & 33

1230

Knee

Routine: AP and Lateral

Additional : PA



Knee Position AP

PFR: Apex of Patella to center of film holder

Film rundown: 8 x 10, DW, NB CR: VP Cone: FFC

Alignment: Part centered. Leg in full extension with Epicondyles parallel to the film.

Demonstrates: Distal femur, proximal tibia and fibula and the interspace.

Notes: FFD 40" ID: Either lateral border

1. IMMOBILIZATION: Place sandbags on each side of the foot.
2. To show maximum joint space angle the CR 10° Cephalic to the center of the film.

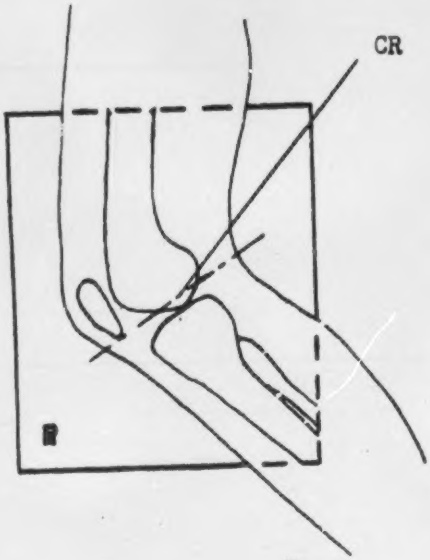
1231

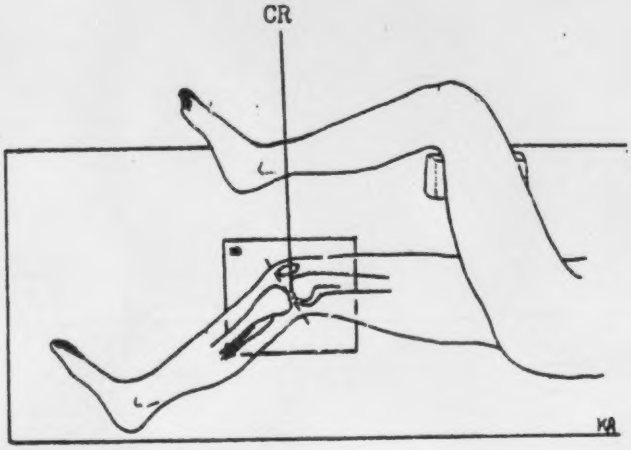
1231

Knee

Routine: AP and Lateral

Additional: PA





Knee Position Lateral

PFR: Midpoint of a line between the apex of the patella and the posterior surface of the knee to the center of the film holder

Film Rundown: 8 x 10, LW, NB CR: VP Cone: FFC

Alignment: Part centered. Epicondyles perpendicular to the film and knee flexed approximately 45°.

Demonstrates: Lateral view of the distal femur, proximal tibia and fibula, patella and the interspace.

Notes: FFD: 40" ID: Lateral border, anterior to part

1. IMMOBILIZATION: Place sandbags across lower leg.
2. Patient laterally recumbant with the unaffected leg crossed over and out of the way.

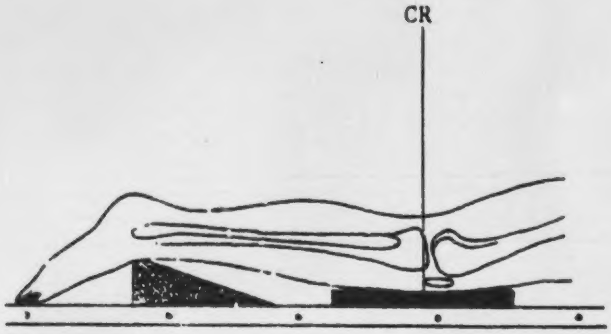
1232

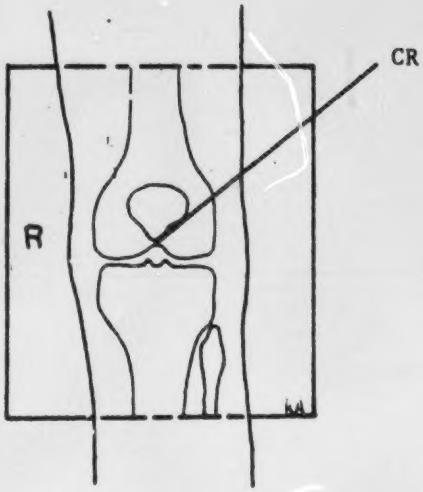
TM 8-280 pp. 10-41 Figure 10-36

Knee

Routine: AP and Lateral

Additional: PA





Knee Position PA

PFR: Apex of patella to center of film holder

Film rundown: 8 x 10, LW, NB CR: VP Cone: FFC

Alignment: Part centered. Leg in full extension with Epicondyles parallel to the film

Demonstrates: Patella, distal femur, proximal tibia and fibula

Notes: FFD 40" ID: Either lateral border

1. IMMOBILIZATION: Place sponge block under ankle and have toes extending off table. This also aids in patient comfort.

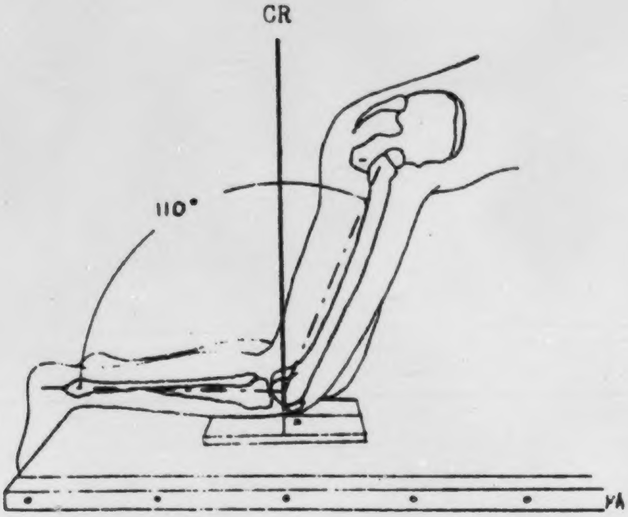
2. This view is taken primarily for better visualization of the patella.

Note: Page 1233 has been omitted. However, all material is included.

TM 8-280 pp. 10-39 Figure 10-34

Knee

Routine: Holmblad



PFR Knee Position Holmblad

XXXX: Apex of patella to center of film holder.

Film rundown: 8 x 10, LW, NB CR: VP Cone: 6"

Alignment: Part centered, Epicondyles parallel with film holder. Femur and leg form an angle of 110°

Demonstrates: Intercondyloid fossa and intercondyloid eminence

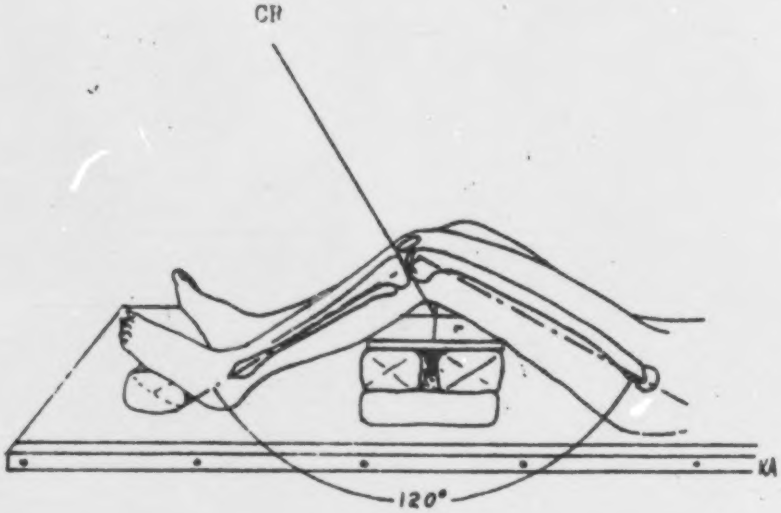
Notes: FFD: 40" ID: Either lateral border in the cone field

1. IMMOBILIZATION: Place sandbags against each side of leg under study.
2. Patient on hands and knees with weight shifted to hands and unaffected knee.
3. Holmblad is the position of choice over Beclare because of less part magnification due to object film distance (OFD)

TM 8-280 pp. 10-42 Figure 10-37

Knee

Routine: Beclere



Knee Position Beclere

CRPR: Apex of patella projected to center of film holder.

Film Rundown: 8 x 10, CW, NB CR: Cephalic and perpendicular to tibia Cone: 6"

Alignment: Part centered. Epicondyles parallel to film. Femur and leg form an angle of 120°

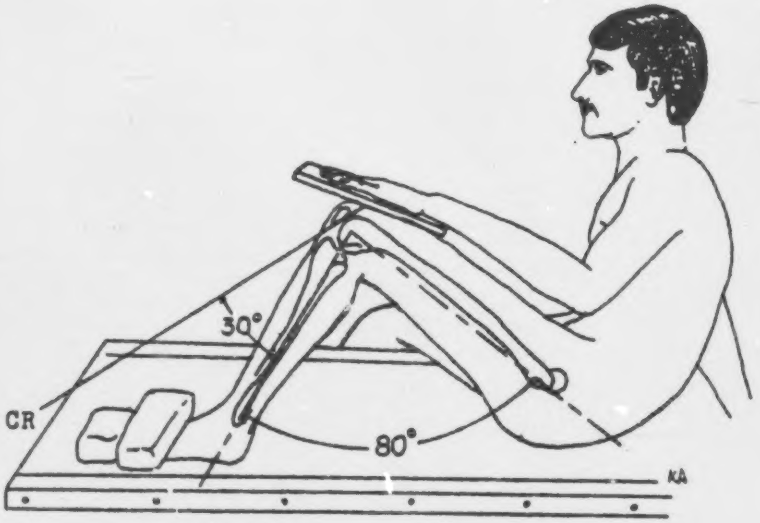
Demonstrates: Intercondyloid fossa and intercondyloid eminence

Notes: FFD: 40" ID: Either lateral border within the conefield

1. IMMOBILIZATION: Place sandbags against each side of the foot and leg under study.
2. The film is positioned parallel to table top and supported on sandbags to bring it in close contact with the posterior aspect of the knee.
3. Do Beclere knee if patient cannot assume the Holmblad position.

TM 8-280 pp. 10-42 Figure 10-37

Patella, Axial Projection (Settegast, Supine Position)



Knee Position (Supine) Settegast

CRPR: Apex of patella projected to center of film holder

Film rundown: 8 x 10, LW, NB CR: Cephalic to form 30° angle to tibia Cone: 6"

Alignment: Part centered. Epicondyles parallel to film. Femur and Tibia form an angle of 80°

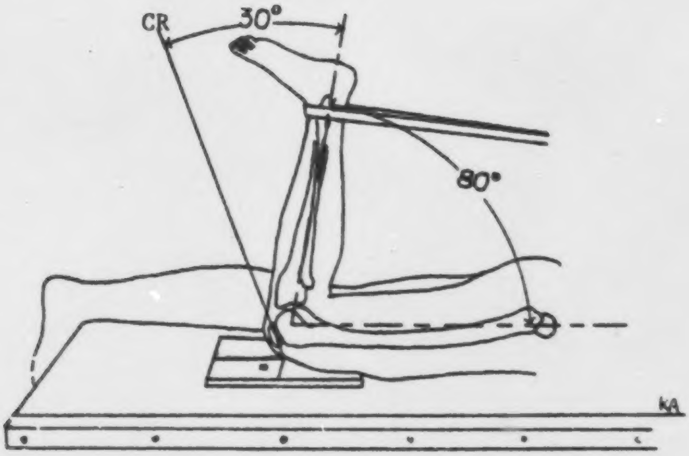
Demonstrates: Axial view of patella and femoral patellor interspace

Notes: FFD: 40" ID: Either lateral border within the conefield

1. IMMOBILIZATION: Place sandbag over the foot of side under study.
2. Patient seated or supine holding film flat against anterior aspect of thigh.
3. Do supine position if patient cannot assume prone position.

TM 8-280 pp. 10-43 Figure 10-38

Patella, Axial Projection (Settegast, Prone Position)



Knee Position (Prone) Settegast

CRPR: Apex of patella projected to center of film holder

Film rundown: 8 x 10, L W, N B CR: Cephalic to form 30° angle to Tibia Cone: 6 "

Alignment: Part centered, Epicondyles parallel to film, Femur and Tibia form an angle of 80°

Demonstrates: Axial view of Patella and Femoral Patellar Interspace

Notes: FFD: 40 " ID: Either lateral border within the conefield

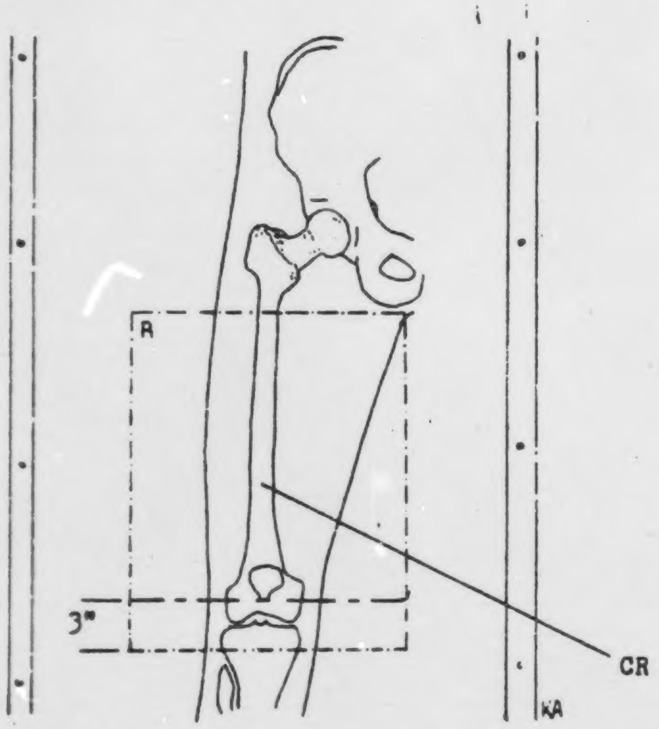
1. IMMOBILIZATION: Use belt-type traction around ankle
2. Prone Settegast is the position of choice because of the limitations of equipement.

TM 8-280 pp. 10-43 Figure 10-38

1238

Femur

Routine: AP and Lateral (Proximal or Distal)



Femur Position AP Distal

PFR: Apex of Patella : 3" above lower border of film holder

Film Rundown: 14 x 17, L W, B CR: VP Cone: FFC

Alignment Epicondyles parallel with table top and a plane thru the ASIS and mid-Epicondyles over the center line of table

Demonstrates: Knee joint and distal 2/3 of the Femur

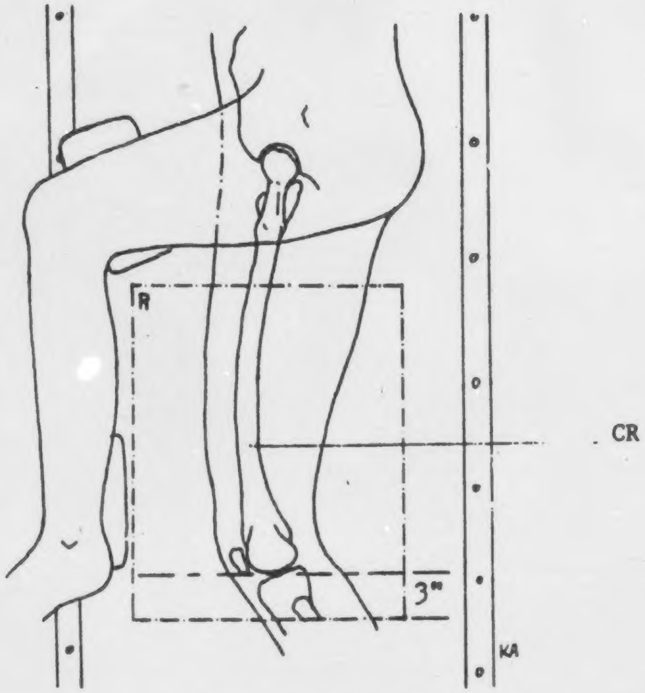
Notes: FFD: 40 " ID: Either lateral border

1. IMMOBILIZATION: Place sandbags against both sides of leg.
2. Cathode Reference: Cephalic
3. Patient Dress: Clothing from waist down removed and dressed in a gown.

1239

Femur

Routine: AP and Lateral (Proximal or Distal)



Femur Position Lateral Distal

PFR: Apex of Patella 3" above lower border of film holder

Film Rundown: 14 x 17, L W, B CR: VP Cone: FFC

Alignment: Epicondyles perpendicular, and a plane thru Greater Trochanter and midmedial surface of the knee over the center line of the table. Knee flexed approximately 45°

Demonstrates: Knee joint and distal 2/3 of Femur

Notes: FFD: 40 " ID: Either lateral border

IMMOBILIZATION: Place sandbag across leg of affected side and support unaffected extremity on sandbag.

Patient Dress: Clothing from the waist down removed and dressed in a gown.

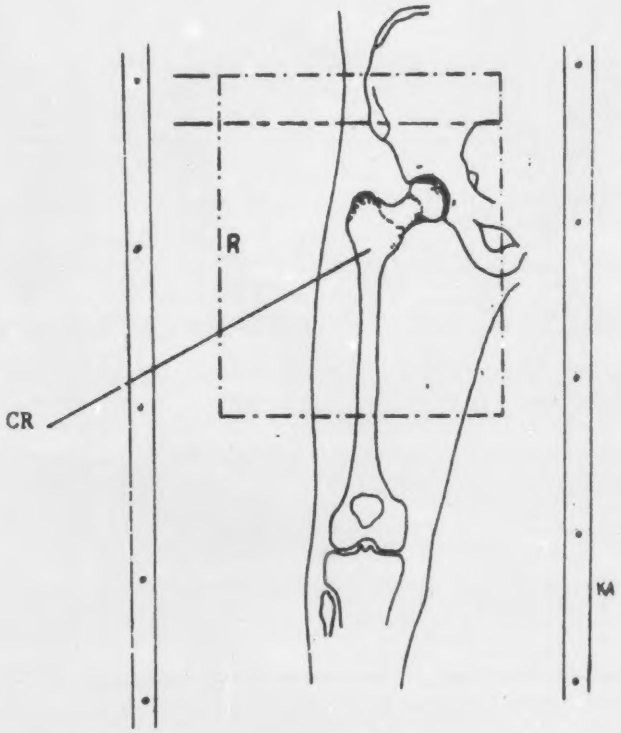
Draw unaffected leg forward, as shown in graph and rest on sandbags.

TM 8-280 pp. 10-45 Figure 10-40

1240

Femur

Routine: AP and Lateral (Distal or Proximal)



Femur Position AP Proximal

PFR: ASIS 3" below upper border of film holder

Film Rundown: 14 x 17, LW, B CR: VP Cone: FFC

Alignment: Epicondyles parallel with table top and a plane thru ASIS and mid-Epicondyles over center line of table

Demonstrates: Hip joint and proximal 2/3 of Femur

Notes: FFD: 40 " ID: Either lateral border

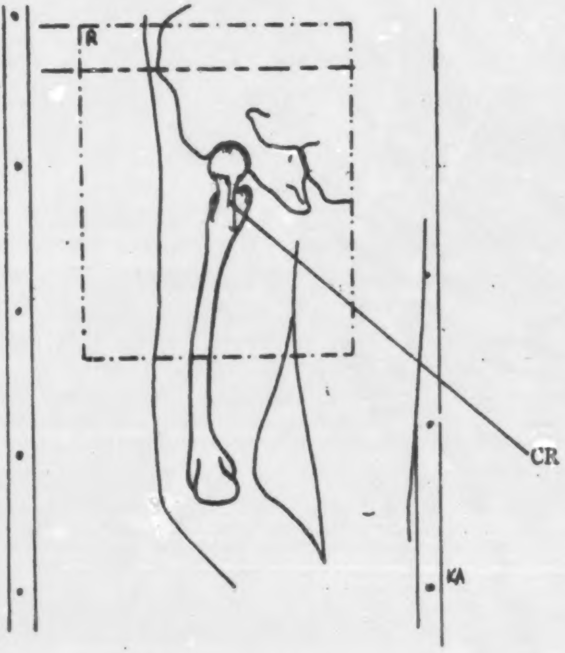
1. IMMOBILIZATION: Place sandbags against both side of the leg.
2. Cathode Reference: Cephalic
3. Patient Dress: Clothing from the waist down removed and dressed in gown

TM 8-280 pp. 10-44 Figure 10-39

1241

Femur

Routine: AP and Lateral (Distal or Proximal)



Femur **Position** Lateral Proximal

PFR: ASIS 3" below upper border of film holder.

Film Rundown: 14x17, L W, B **CR:** VP **Cone:** FFC

Alignment: Epicondyles perpendicular and a plane thru the Greater Trochanter and the mid-medial surface of the knee over the center line of the table. Knee flexed approximately 45°

Demonstrates: Hip joint and proximal 2/3 of femur

Notes: FFD: 40 " ID: Either lateral border

1. IMMOBILIZATION: Place sandbag across leg of affected side.
2. Cathode Reference: Cephalic
3. Patient Dress: Remove clothing from waist down and dressed in a gown
4. With patient laterally recumbant, bring unaffected femur backwards to prevent super-imposition of femurs. Also patient can grasp side of table to aid in maintaining the position.

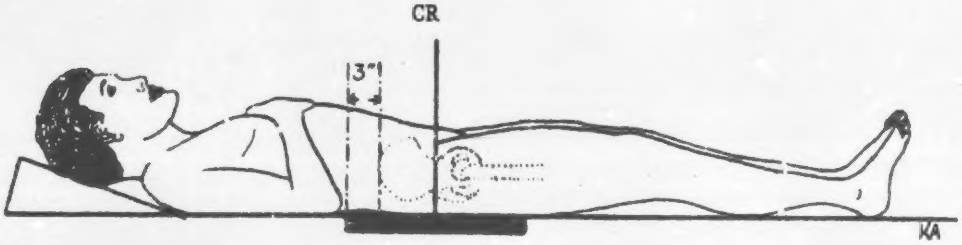
TM 8-280 pp. 10-45 Figure 10-40

1242

Pelvis

Routine: AP

Additional: Spread or Frog Position



Pelvis **Position** AP

PFR: Plane thru Iliac Crests 3" below upper border of the film holder

Film Rundown: 14 x 17, C W, B **ID:** Either lateral border

CR: VP **Cone:** FFC

Alignment: Vertabral column over center line of table, lower extremities fully extended, with feet and legs rotated 15° medially

Breathing Technique: Suspended Respiration **FFD:** 40"

Demonstrates: Bony structures of the pelvic girdle

Notes: 1. IMMOBILIZATION: Place sandbags against both feet.

2. To prevent foreshortening of the heads and necks of femurs, rotate feet and legs 15° medially

3. Patient Dress: Clothing from waist down removed and dressed in a gown.

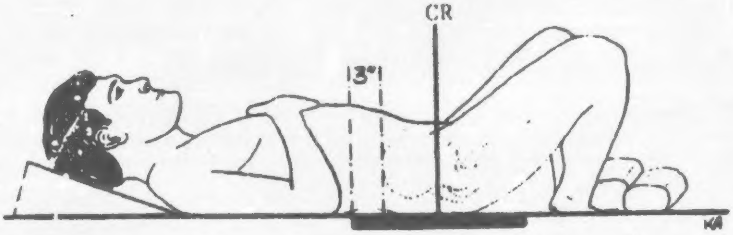
4. Cathode Reference: Caudad

TM 8-280 pp. 10-50 Figure 10-45

Pelvis

Routine: AP

Additional: Spread or "Frog" Position



Pelvis Position Spread

PFR: Plane thru Iliac Crests 3" below upper border of film holder

Film Rundown: 14 x 17, CW, B TD: Either lateral border

GR: VP Cone: FFC

Alignment: Vertebral column over center line of table. Soles of feet placed together and thighs are equally abducted as far as injury will permit. (Approx 80°)

Breathing Technique: Suspended respiration FFD: 40"

Demonstrates: Lateral projection of the head and neck of both femurs.

Notes: 1. IMMOBILIZATION: Place sandbags against both feet and supporting both legs.

2. Patient dress: Same as AP

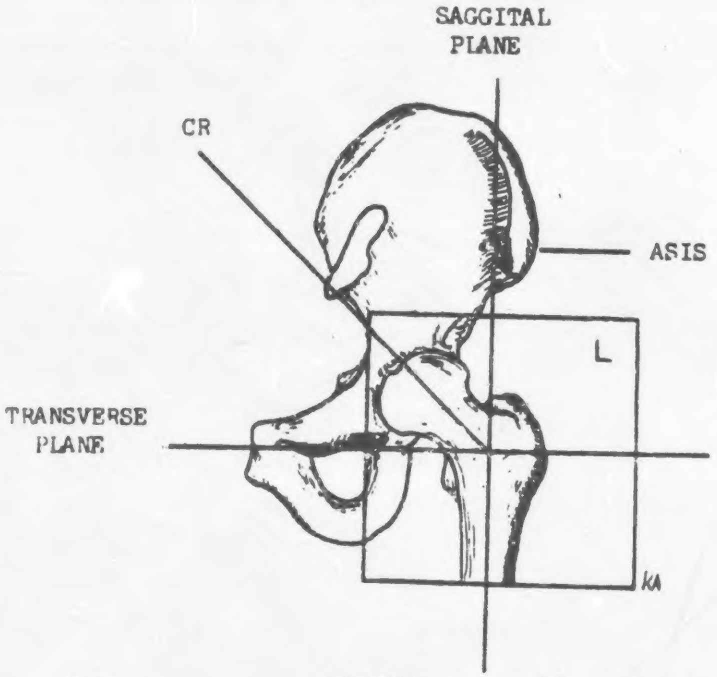
3. Cathode Reference: Caudad

4. TM 8-280 Spread pelvis is explained with 10° cephalic CR and PFR: Plane thru the Iliac Crests 4" below upper border of film holder. Both methods are acceptable.

TM 8-280 pp. 10-49 Figure 10-44

Hip

Routine: AP Pelvis, AP and Lateral Hip



Hip Position AP

PFR: Intersection of the Sagittal Plane (Paramedian) through the ASIS and the transverse plane thru the Greater Trochanter to center of film holder.

Film Rundown: 10 x 12, LW, B ID: Lateral to part within conefield

CR: VP Cone: 8"

Alignment: Part centered, with foot and leg rotated 15° medially

Breathing Technique: Suspended Respiration FFD: 40"

Demonstrates: AP head and neck of Femur and Acetabulum

Notes: 1. IMMOBILIZATION: Place sandbags against side of both feet.

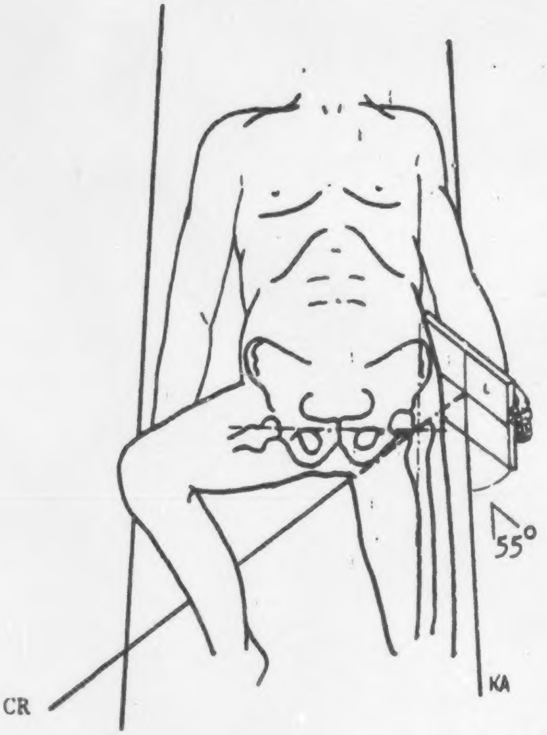
2. Patient Dress: Clothing from waist down removed and dressed in gown

TM 8-280 pp. 10-46 Figure 10-41

1245

Hip

Routine: AP Pelvis, AP and Lateral Hip



Hip Position Lateral

PFR: Intersection of the Sagittal Plane (Paramedian) thru the ASIS and the transverse plane thru the Greater Trochanter to center of the film holder.

Film Rundown: 10 x 12, LW, Grid Cassette ID: Above the part within the cone field.

CR: HP Cone: 8"

Alignment: Part centered, affected extremity fully extended, foot and leg rotated 15° medially

Breathing Technique: Suspended Respiration FFD: 40"

Demonstrates: Lateral view of head and neck of femur and acetabulum

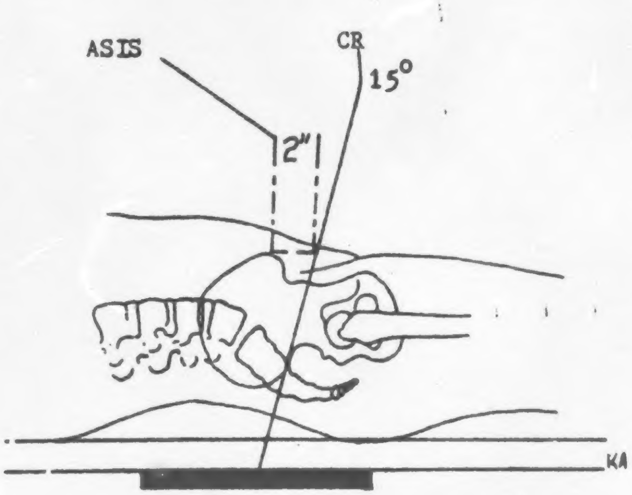
Notes:
1. IMMOBILIZATION: Place sandbags against both sides of leg.
2. Patient is supine and moved to the outer edge of the table and the unaffected leg is drawn up and out of the way and placed on a support. (stool)
3. (INSTRUCTORS NOTE) Explain 55° as shown on the graph above.

TM 8-280 pp. 10-47 Figure 10-42 1245

1246

Sacrum

Routine: AP and Lateral



Sacrum Position AP

CRPR: A point 2" below mid-ASIS plane projected to center of film holder

Film Rundown: 10 x 12, LW, B ID: Either lateral border within conefield

CR: 15° Cephalic Cone: 8"

Alignment: Part centered, Median plane over centerline of table

Breathing Technique: Suspended Respiration FFD: 40"

Demonstrates: AP Sacrum

Notes: 1. Lower extremities fully extended

2. Patient Dress: Clothing from waist down removed and dressed in gown

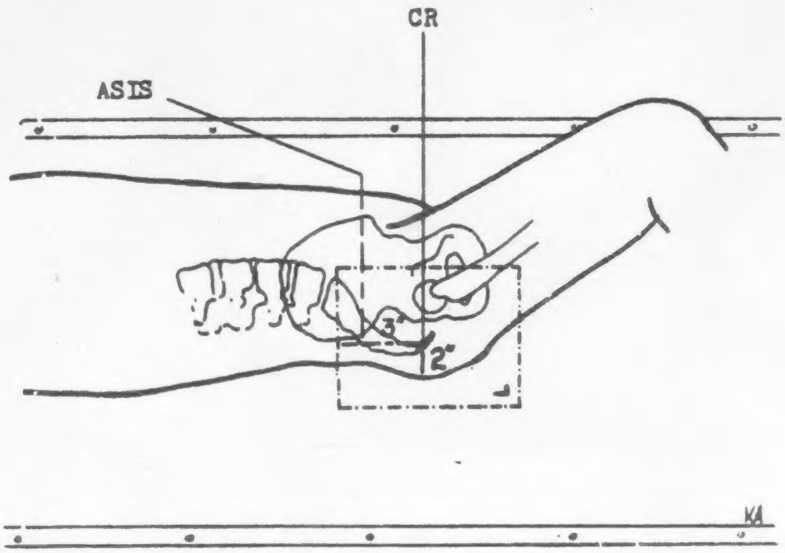
3. Suspended respiration aids in immobilization.

1246

TM 8-280 pp. 10-79 Figure 10-72

Coccyx

Routine: AP and Lateral



Coccyx Position Lateral

PFR: A point 2" anterior to posterior skin surface, at a level 3" below the ASIS to center of the film holder.

Film rundown: 8 x 10, LW, B ID: Either lateral border within the conefield

CR: VP Cone: 6 "

Alignment: Coronal plane perpendicular to table

Breathing Technique: Suspended respiration FFD: 40 "

Demonstrates: Lateral Coccyx

Notes: 1. IMMOBILIZATION: Legs flexed forward for patient comfort and to aid in immobilization.

2. Patient Dress: Clothing from waist down removed and dressed in gown

TM 8-280 pp. 10-79 Figure 10-73

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1250

SFC J. BINKLEY
SFC R. GORDON

*GR 38-520-027-1B
047

X-RAY BRANCH

TO CONSERVE FIGHTING STRENGTH

313-91P20

RADIOGRAPHIC POSITIONING
VOLUME III
TRUNK

MEDICINE AND SURGERY DIVISION
X-RAY BRANCH
FORT SAM HOUSTON, TEXAS 78234

*This general reference supersedes GR 38-520-027-1, 116

TABLE OF CONTENTS

TRUNK

PAGE

Objectives 2
Positioning of the Cervical Spine - Anterior Posterior 3
Positioning of the Cervical Spine - Open Mouth 4
Positioning of the Cervical Spine - Lateral 5
Positioning of the Cervical Spine - Moving Jaw 6
Positioning of the Cervical Spine - Flexion - Extension 7
Positioning of the Cervical Spine - Oblique 8
Positioning of the Dorsal Spine - Anterior Posterior 9
Positioning of the Dorsal Spine - Lateral 10
Positioning of the Dorsal Spine - Oblique 11
Positioning of the Lumbar Spine - Anterior Posterior 12
Positioning of the Lumbar Spine - Lateral 13
Positioning of the Lumbar Spine - Oblique 14
Positioning of the Lumbosacral Articulation - Anterior Posterior 15
Positioning of the Lumbosacral Articulation - Lateral 16
Positioning of the Sacroiliac Articulation - Oblique 17
Positioning of the Chest - Anterior Posterior 18
Positioning of the Chest - Lateral 19
Positioning of the Chest - Oblique 20
Positioning of the Chest - Lordotic 21
Table of Oblique Ribs 22
Positioning of the Ribs - Anterior Posterior (Above Diaphragm) 23
Positioning of the Ribs - Right & Left Anterior Obliques (Above Diaphragm) 24
Positioning of the Ribs - Anterior Posterior (Below Diaphragm) 25
Positioning of the Ribs - Left (LPO) and Right (RPO) Posterior Obliques (Above & Below Diaphragm) 26
Positioning of the Abdomen (KUB) Anterior Posterior 27
Positioning of the Abdomen - Upright 28
Positioning of the Abdomen - Upright KUB 29
Positioning of the Sternum - RAO-Right Anterior Oblique 30
Positioning of the Sternum - Lateral 31
Positioning of the Acromioclavicular Joints - Anterior Posterior With and Without Weights 32, 33
Positioning of the Sternoclavicular Joints - Bilateral Oblique 34

OBJECTIVES

1. Identify by name the position and anatomical structures demonstrated.

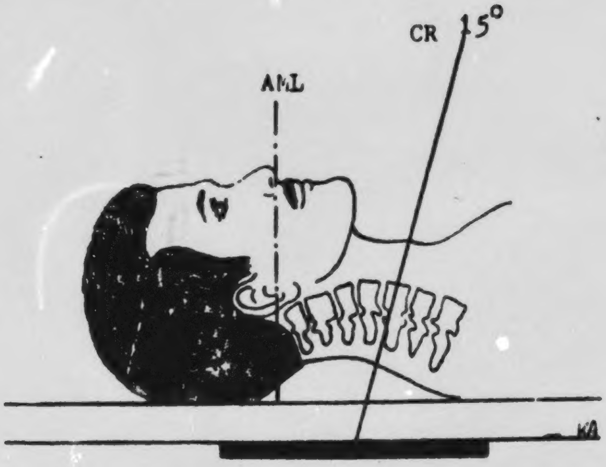
2. Determine the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization, film identification and captioning necessary to demonstrate the position.

3. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiographic position.

Cervical Spine

Routine: AP, Open Mouth and Lateral

Additional: Moving Jaw



Cervical Spine Position AP

CRPR: Midpoint of thyroid cartilage projected to center of film holder

Film Rundown: 10 x 12, LW, B ID: Either lateral border

CR: 15° Cephalic Cone: FFC

Alignment: Median plane and Acanthiomeatal line perpendicular to film.

Breathing Technique: Suspended Respiration FFD: 40 "

Demonstrates: Lower 5 cervical vertebrae and soft tissue

Notes: 1. Median plane to center line of table.

2. * First two way head alignment

3. All artifacts removed (dentures, necklaces, eye glasses etc.) This applies to all views of the cervical spine

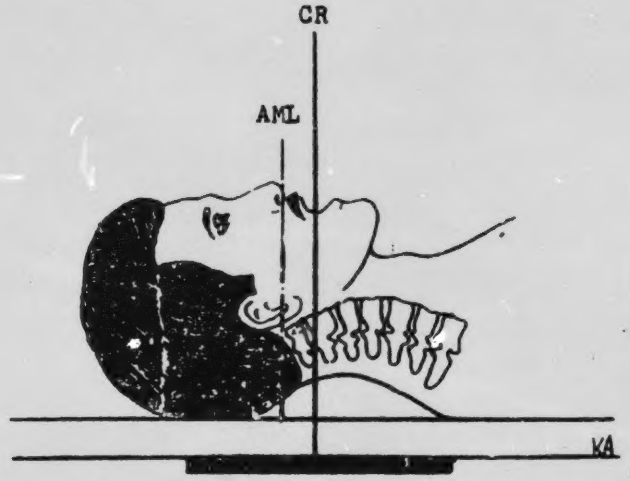
4. With all views of the spinal region, handle the patient with extreme care.

1254

Cervical Spine

Routine: AP, Open Mouth and Lateral

Additional: Moving Jaw



Cervical Spine Position Open Mouth

PFR: Midpoint of open mouth to center of film holder

Film Rundown: 8 x 10, L W, B ID: Either lateral border withing conefield

CR: VP Cone: 6 "

Alignment: Median plane and Acanthio-meatal line perpendicular to film

Breathing Technique: Suspended Respiration FFD: 40"

Demonstrates: C-1 and C-2 (Primarily for C-2 and the Odontoid Process)

Notes: 1. Median plane to center line of table

2. First two way head alignment

3. All artifacts removed (dentures, necklaces, eye glasses etc.) This applies to all views of the cervical spine.

4. With all views of the spinal region, handle the patient with extreme care

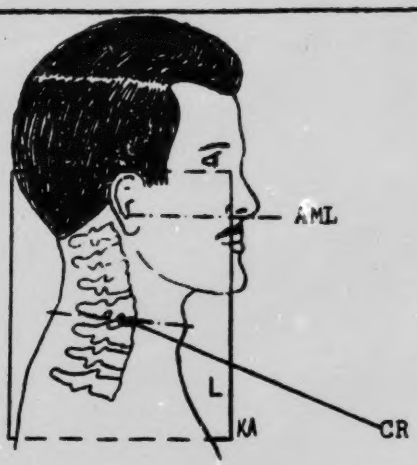
TM 8-280 pp. 10-68 Figure 10-62

1255

Cervical Spine

Routine: AP, Open Mouth, and Lateral

Additional: Moving Jaw



Cervical Spine Position Lateral

PFR: Mid-point of the neck at the level of the Thyroid Cartilage to center of film holder.

Film Rundown: 10 x 12, L W, NB ID: Either lateral border

CR: H P Cone: FFC

Aligament: Median plane parallel to film, Acanthio-meatal line parallel to floor

Breathing Technique: Suspended Respiration for immobilization FFD: 72 "

Demonstrates: All seven (7) cervical vertebrae

Notes: 1. Place sandbags of equal weight in hands to bring shoulders down to ensure visualization of C-7

2. 72 " FFD is used to minimize magnification because of large OFD.

3. Patient may be standing or seated erect

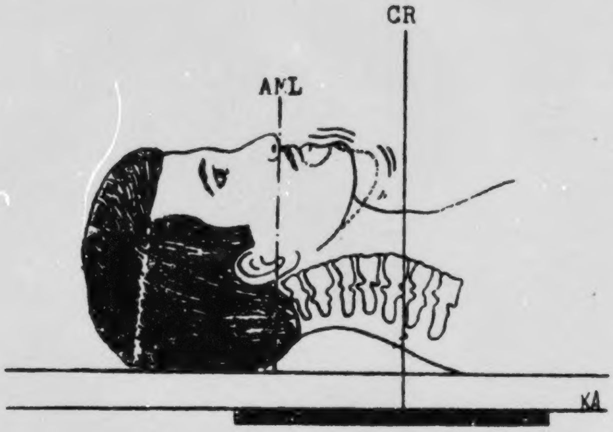
TM 8- 280 pp. 10-69 Figure 10-63

1256

Cervical Spine

Routine: AP, Open Mouth and Lateral

Additional: Moving Jaw



Cervical Spine Position Moving Jaw

PFR: Mid-point of the Thyroid Cartilage to the center of the film holder

Film Rundown: 10 x 12, L W, B ID: Either lateral border

CR: V P Cone: FFC

Alignment: Median plane and Acanthio-meatal line perpendicular to film.

Breathing Technique: Suspended Respiration for immobilization FFD: 40 "

Demonstrates: All seven (7)cervical vertebrae

Notes: 1. Median plane to center line of table

2. First two way head alignment

3. All artifacts removed (dentures, necklaces, eye glasses etc.) This applies to all views of the cervical spine.

4. With all views of the spinal region handle the patient with extreme care

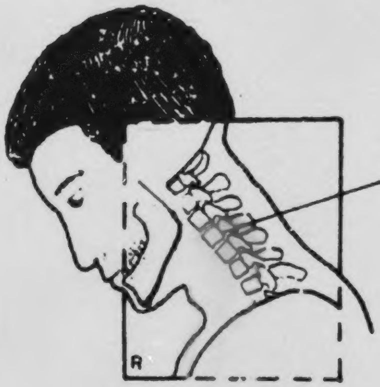
5. Utilize a minimum exposure time of 3-5 seconds.

1254

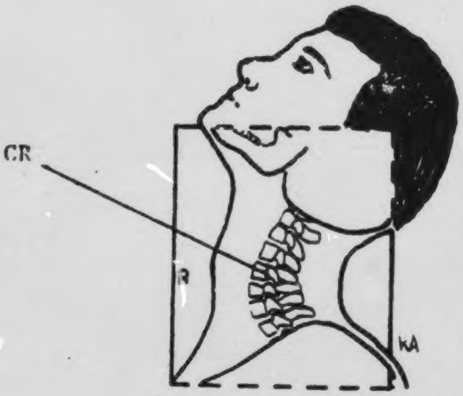
TM 8-280 pp. 10-67 Figure 10-61 (Variation)

1257

Flexion and Extension Cervical Spine Positions



Projection 1: Flexion



Projection 2: Extension

Additional Cervical Spine Positions: Flexion and Extension

PFR: Mid-point of neck at the level of Thyroid Cartilage to center of film holder

Film rundown: 10 x 12, L W, NB ID: Either lateral border

CR: H P Cone: FFC

Alignment: Median plane parallel to the film

Breathing Technique: Suspended Respiration for immobilization FFD: 72 "

Demonstrates: All seven (7) cervical vertebrae in extreme flexion and extension

Notes: 1. PFR is obtained with patient in normal lateral position

2. Sandbags of equal weight are placed in each hand to bring shoulders down

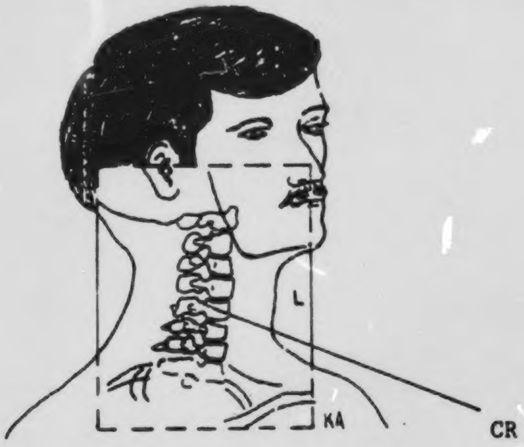
3. These two views are taken to determine the mobility of the cervical vertebrae

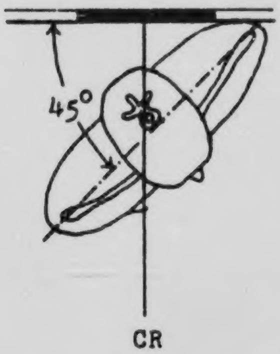
TM 8-280 pp. 10-69 Figure 10-63 (Variation)

Cervical Spine

Routine: AP, Open Mouth and Lateral

Additional: Oblique





Cervical Spine Position Oblique (LPO and RPO)

CMPR: Mid-point of the neck at the level of the Thyroid Cartilage to the center of the film holder

Film rundown: 10x12, L W, B TD: Either lateral border

CP: 15° Cephalic Cone: FFC

TWHA: Median Plane 45°, and Acanthio-meatal line perpendicular to film.

Breathing Technique: Suspended Respiration for immobilization FFD: 40 "

Demonstrates: Cervical vertebrae with emphasis on intervertebral foramina

Notes: 1. Both obliques are taken for comparison.

2. Demonstrates side away from the film, patient may be standing or seated erect.

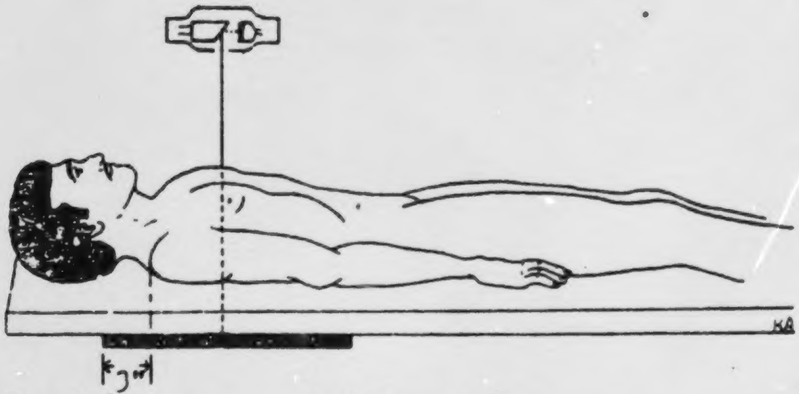
Variations: 1. 72 " FFD, Non-bucky, CR, Horizontal Perpendicular (H P) all other information remains the same.

2. PA Obliques may be taken utilizing 40 " FFD, 15° Caudad CR, All other information remains the same

1259

Dorsal Spine

Routine: AP and Lateral



Dorsal Spine Position A P

PFR: Plane thru Acromion Process 3" below upper border of film holder

Film Rundown: 14 x 17, L W. B ID: Either lateral border

CR: V P Cone: FFC

Alignment: Median plane perpendicular and over center line of table.

Breathing Technique: Suspended Expiration for uniform density FFD: 40 "

Demonstrates: All twelve (12) dorsal vertebrae and paraspinal soft tissue

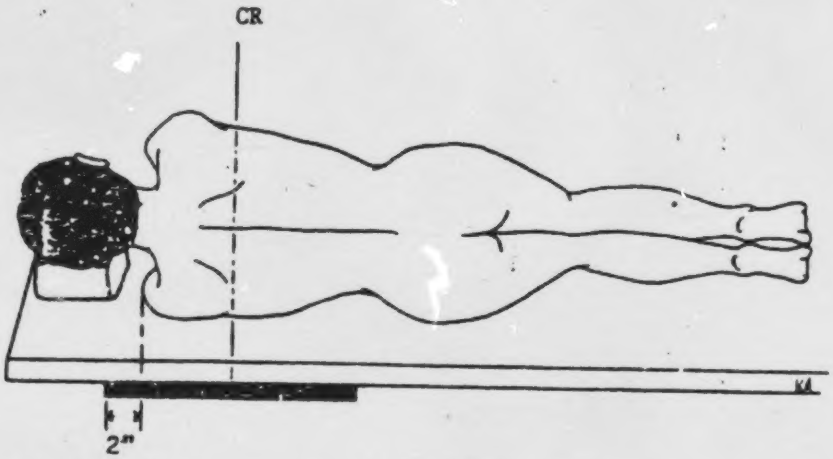
Notes: 1. Cathode Reference: Caudad, for uniform density

2. Patient Dress: Clothing from waist up removed and patient dressed in gown.

1260

Dorsal Spine

Routine: AP and Lateral



Dorsal Spine Position Lateral

PFR: Plane thru Acromion Process 2" below upper border of film holder

Film Rundown: 14 x 17, L W, B ID: Lateral border posterior to part

CR: V P Cone: FFC

Alignment: Coronal perpendicular to table and over center line of table.

Breathing Technique: Suspended Expiration for uniform density FFD: 40 "

Alternate Breathing Technique: Normal Breathing with long exposure time (3-5 seconds) to blur out vascular markings.

Demonstrates: 4 thru 12 dorsal vertebrae and interspaces

Notes: 1. Coronal Plane (Acromion Process to Superior Prominence of Iliac Crest)

2. Buttress if necessary to bring the spine parallel to film, using radiolucent material in the area of the waist.

3. Patient Dress: Clothing from waist up removed and patient dressed in gown.

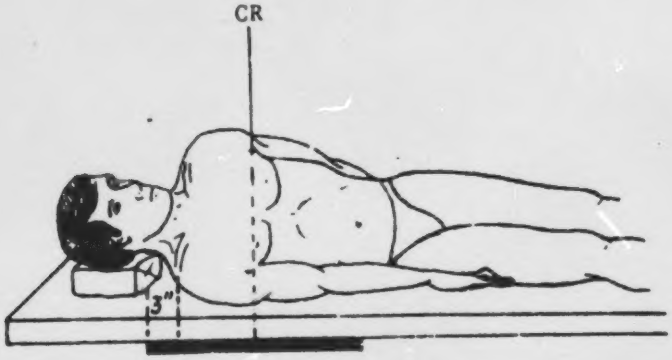
4. Knees flexed and arms at 90° to body to aid in immobilization.

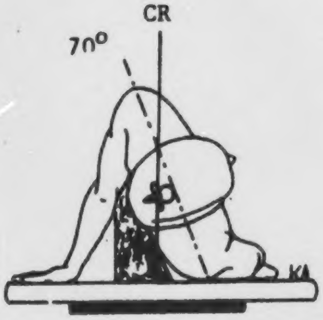
1255

TM 8-280 pp. 10-72 Figure 10-66

Oblique Dorsal

Routine: AP and lateral





Dorsal Spine Position Oblique (RPO and LPO)

PFR: Plane thru Acromion Process 3" below upper border of the film holder

Film Rundown: 14 x 17, L W, B ID: Either lateral border

CR: V P Cone: FFC

Alignment: Coronal plane 70° from table adjust spine to center line of table

Breathing Technique: Suspended Expiration for uniform density FFD: 40 "

Demonstrates: Dorsal spine with emphasis on apophyseal joints and articular processes

Notes: 1. From true lateral rotate patient backwards until Coronal plane forms a 70° angle with table.

2. IMMOBILIZATION: Use sponge positioning blocks for buttressing material

3. Elevated arm is posterior behind patients back

4. Patient Dress: Clothing from waist up removed and patient dressed in gown

5. Side away from film is best demonstrated

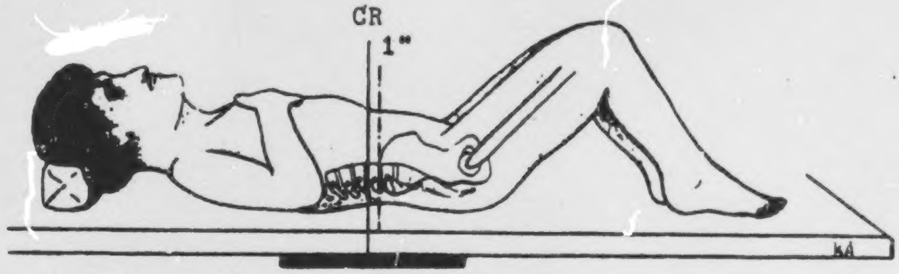
6. Both obliques are taken

TM 8-280 pp. 10-74 Figure 10-68

1262

Lumbar Spine

Routine: AP and Lateral



Lumbar Spine Position A P

Plane thru Superior Prominence of Iliac Crest

PFR: 1 " below center of film holder

Film Rundown: 14 x 17, L W, B ID: Either lateral border

CR: V P Cone: FFC

Alignment: Median plane perpendicular and over center line of table.

Breathing Technique: Suspended Respiration for immobilization FFD: 40 "

Demonstrates: Lumbar vertebrae and interspaces, soft tissues

Notes: 1. Cathode Reference: Caudad

2. Knees flexed with soles feet flat on table to lessen the lordotic curvature.

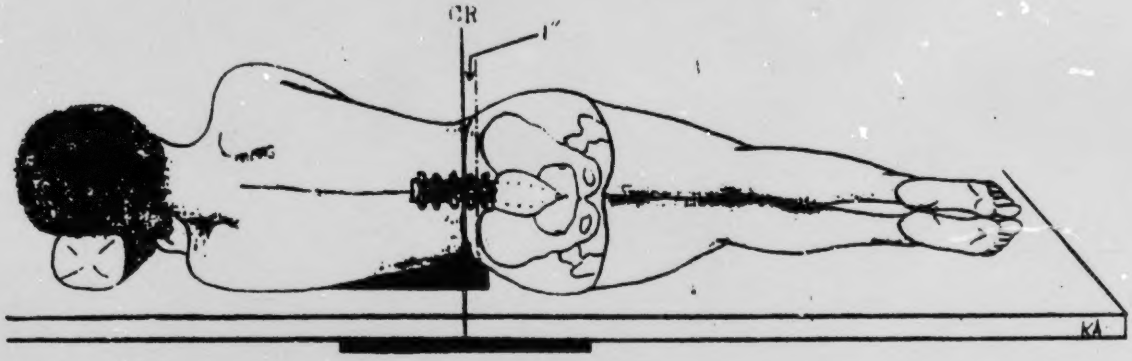
3. Patient Dress: Clothing from waist down removed and dressed in gown

1260

TM 8-280 pp. 10-75 Figure 10-69

Lumbar Spine

Routine: AP and Lateral



Lumbar Spine Position Lateral

PFR: Plane thru Superior Prominence of the Iliac Crest 1" below center of film holder

Film Rundown: 14 x 17, L W, B ID: Either lateral border

CR: V P Cone: FFC

Alignment: Coronal Plane perpendicular and over center line of table

Breathing Technique: Suspended Respiration for immobilization FFD: 40"

Demonstrates: Lumbar Vertebrae and interspaces, soft tissues

Notes: 1. Cathode Reference: Caudad

2. Use radiolucent buttressing material under waist to place the spine parallel to the table.

3. Coronal Plane Reference: From the Acromion Process to the Superior Prominence of the Iliac Crest.

4. Knees flexed, and arms at 90° to body to aid in stability

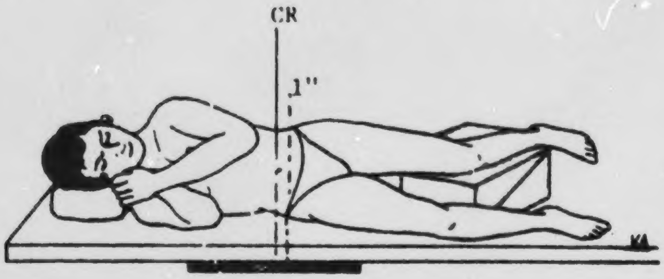
5. Patient Dress: Clothing from waist down removed and dressed in gown.

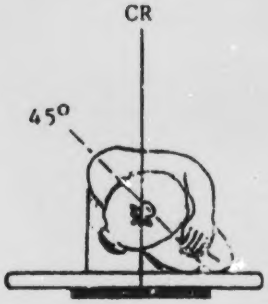
TM 8-280 pp. 10-76 Figure 10-70

1264

Oblique Lumbar

Routine: AP and Lateral





Lumbar Spine Position Oblique (LPO and RPO)

PFR: Plane thru Superior Prominence of Iliac Crests 1" below center of film holder

Film Rundown: 14 x 17, L W, B ID: Either lateral border

CR: V P Cone: FFC

Alignment: Coronal Plane 45° to table, adjust spine over center line of table

Breathing Technique: Suspended Respiration for immobilization FFD: 40"

Demonstrates: Apophyseal Joints and Articular Processes closest to film

Notes: 1. Both obliques are taken

2. To immobilize patient, use sponge positioning blocks for buttressing material

3. Patient Dress: Remove clothing from the waist down and dressed in gown

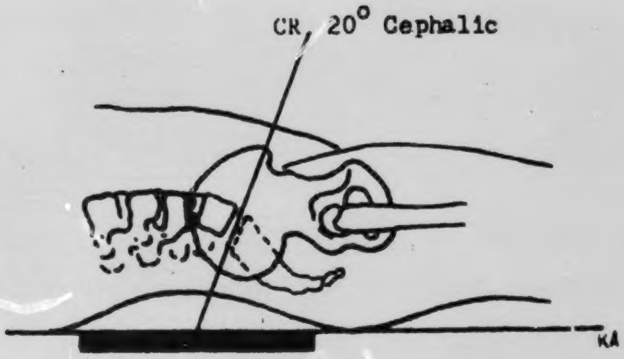
1262

TM 8-280 pp. 10-77 Figure 10-71

1265

Lumbosacral Articulation

Routine: AP and Lateral



Lumbosacral Articulation Position A P

CRPR: Midpoint between the ASIS projected to center of film holder

Film Rundown: 10 x 12, L W, B ID: Either lateral border within cone field

CR: 20° Cephalic Cone: 8 "

Alignment: Median Plane over center line of table

Breathing Technique: Suspended Respiration for immobiliz FFD: 40 "

Demonstrates: Lumbosacral and Sacroiliac Articulation

Notes: 1. Legs are not flexed

2. Patient Dress: Clothing from waist down removed and dressed in gown.

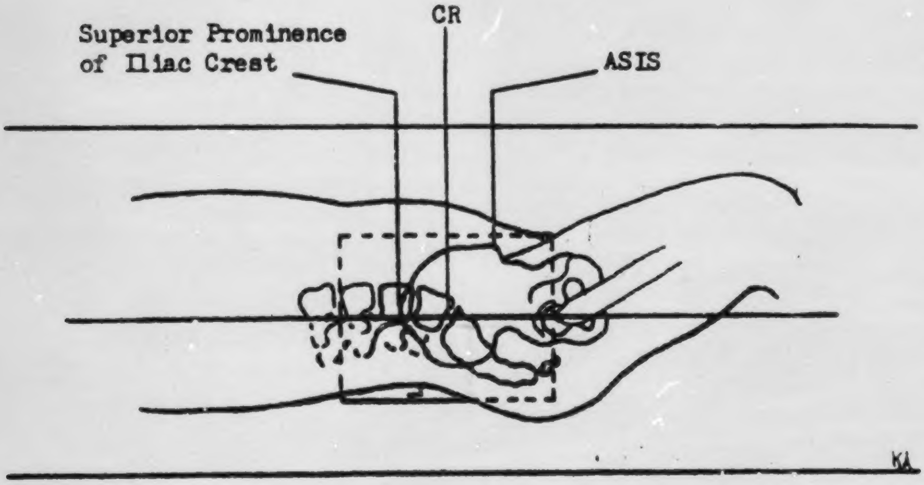
1263

TM 8-280 pp. 10-78 Figure 10-72

1266

Lumbosacral Articulation

Routine: AP and Lateral



Lumbosacral Articulation Position Lateral

PFR: Point on the Coronal Plane, midway between the ASIS and the Superior Prominence of the Iliac Crest to center of film holder.

Film Rundown: 10 x 12, L W, B ID: Either lateral border within cone field

CR: V P Cone: 8 "

Alignment: Coronal Plane perpendicular and over center line of table

Breathing Technique: Suspended Respiration FFD: 40 "

Demonstrates: Lumbosacral Articulation

Notes: 1. Coronal Plane Reference: From the Acromion Process to the Superior Prominence of the Iliac Crest.

2. Use buttressing to bring spine parallel to table

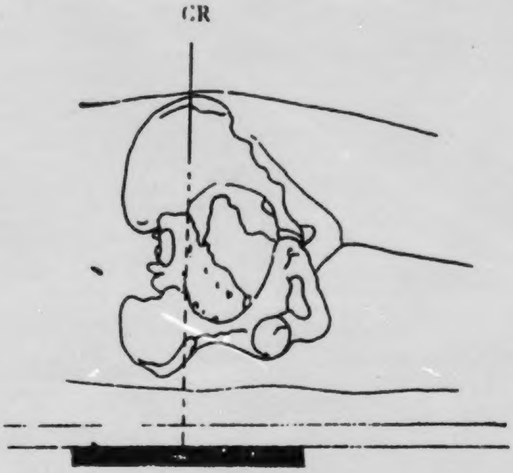
3. Patient Dress: Clothing from waist down removed and dressed in a gown

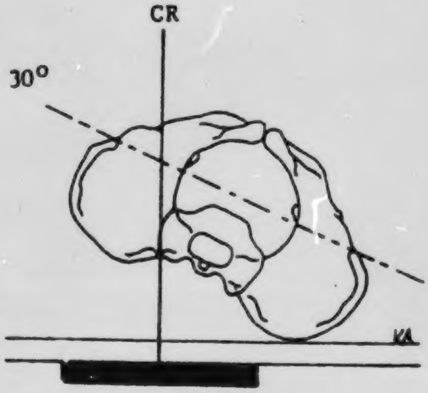
1264

TM 8-280 pp. 10-79 Figure 10-73

Oblique Sacroiliac Articulation

Routine: Bilateral





Sacroiliac Articulation Position Oblique (RPO and LPO)

PFR: A point 1" medial of the elevated ASIS to center of film holder

Film Rundown: 10 x 12, L W, B ID: Either lateral border within conefield

CR: V P Cone: 8 "

Alignment: Coronal plane rotated 30° oblique. Hips and shoulders in same plane.

Breathing Technique: Suspended Respiration FFD: 40 "

Demonstrates: Sacroiliac Articulation (Elevated Side)

Notes: 1. Buttress patient using sponge blocks

2. Both sides are taken for comparison

3. Patient Dress: Clothing from waist down removed and dressed in gown

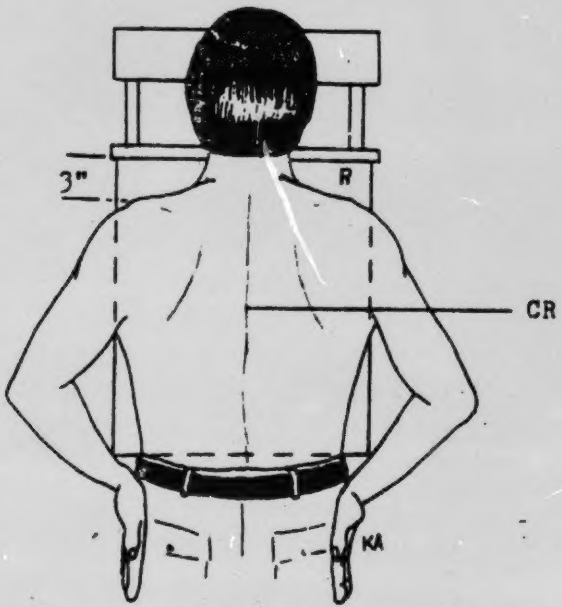
TM 8-280 pp. 10-80 Figure 10-74

1268

Chest

Routine: PA

Additional: Lateral, Oblique, and Lordotic



Chest Position P A

PFR: Acromion Process 3" below upper border of film holder

Film Rundown: 14 x 17, L W, NB ID: Above shoulder reading down

CR: H P Cone: FFC

Alignment: Median Plane perpendicular and over center line of film

Breathing Technique: Suspended Inspiration after second (2) deep breath FFD: 72 "

Demonstrates: Lungs, heart, aorta; secondarily ribs

Notes:
1. Part-to-Film reference is made prior to the patient placing hands on hips.
2. Back of hands are placed on hips, shoulders and elbows are rotated as far forward as possible to remove the Scapula from the lung fields.
3. 72" FFD is used to minimize magnification of the heart shadow.
4. Patient Dress: Male Patients:- clothing from waist up removed

Female Patients:- dressed in gown after removing clothing from waist up

1266

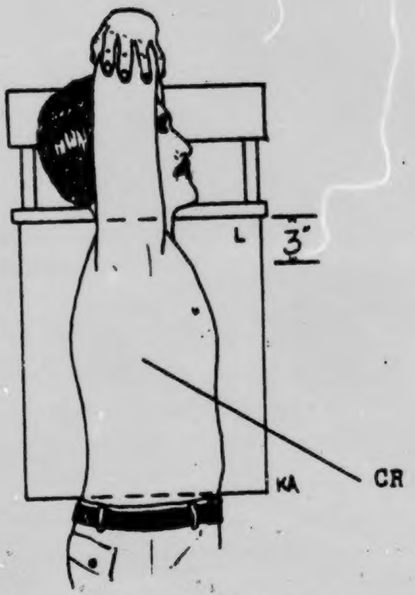
TM 8-280 pp. 10-52 Figure 10-47

1269

Chest

Routine: PA

Additional: Lateral Oblique, and Lordotic



Chest Position Lateral

PFR: Plane thru Acromion Process 3" below upper border of film holder

Film Rundown: 14 x 17, L W, NB ID: Upper border anterior to part

CR: H P Cone: FFC

Alignment: Median Plane parallel to film and trunk centered

Breathing Technique: Suspended Inspiration after second deep breath FFD: 72 "

Demonstrates: Lungs, heart, aorta, interlobar fissures, mediastinum

Notes: 1. Arms up and folded over head.

2. Lung field closest to film is best demonstrated

3. Patient Dress: Male: Clothing from waist up removed
Female: Dressed in gown after removing clothing from waist up

4. The left lateral is preferred, because of less magnification of the heart, due to Object Film Distance (OFD)

1267

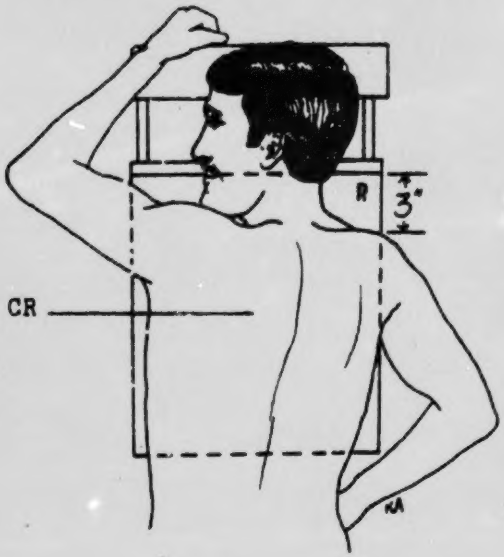
TM 8-280 pp. 10-53 Figure 10-48

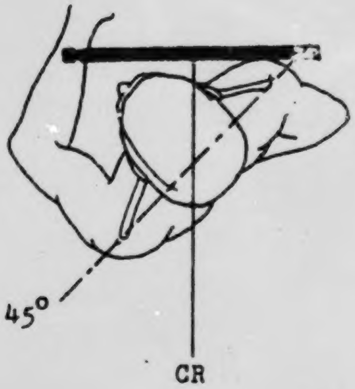
1270

Chest

Routine: PA

Additional: Lateral, Oblique, and Lordotic





Chest Position Oblique (RAO and LAO)

PFR: Acromion Process 3" below upper border of film holder

Film Rundown: 14 x 17, L W, NB ID: Above part reading down

CR: H P Cone: FFC

Alignment: Trunk centered, Coronal Plane 45° to film

Breathing Technique: Suspended Inspiration after second (2) deep breath FFD: 72"

Demonstrates: Best demonstrates lung field furthest from film

Notes: 1. Both obliques of the chest are normally taken, when a full study of the chest area is required.

2. Patient Dress: Male: Clothing removed from waist up

Female: Dressed in gown after removing clothing from waist up

1268

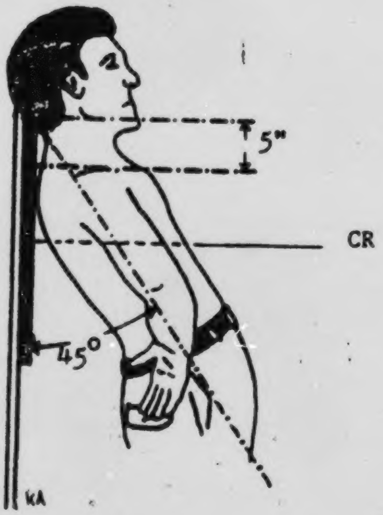
TM 8-280 pp. 10-54 Figure 10-49

1271

Chest

Routine: PA

Additional: Lateral, Oblique, and Lordotic



Chest Position Lordotic

PFR: Acromion Processes 5" below upper border of film holder

Film Rundown: 14 x 17, L W, NB ID: Above part reading down

CR: H P Cone: FFC

Alignment: Trunk centered, with Coronal Plane forming a 45° angle with the film

Breathing Technique: Suspended Inspiration after second (2) deep breath FFD: 72"

Demonstrates: Apices of lungs

Notes: 1. For patient safety, have patient remove high heel shoes

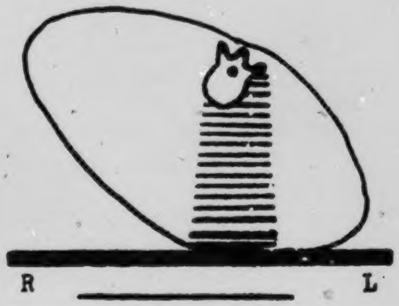
2. Place backs of hands on hips, rotate shoulders and elbows forward to remove Scapula from lung fields.

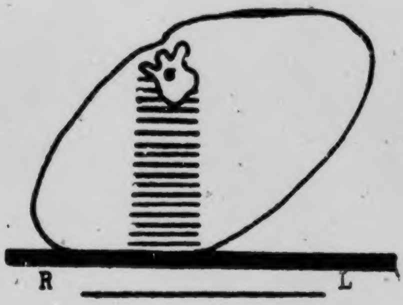
3. Patient Dress: MALE: Remove clothing from the waist up
FEMALE: Dressed in gown after removing clothing from waist up

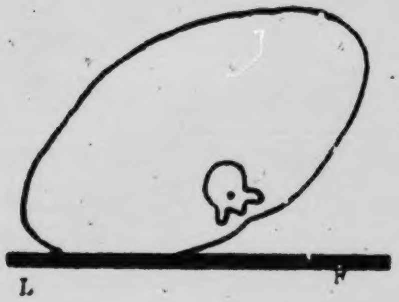
TM 8-280 pp. 10-55 Figure 10-50

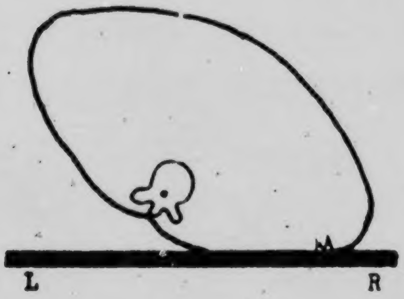
TABLE OF OBLIQUE RIBS

RIB POSITION	DEMONSTRATES	
	ABOVE THE DIAPHRAGM	BELOW THE DIAPHRAGM
LAO 30°	RIGHT ANTERIOR RIBS	N/A
RAO 30°	LEFT ANTERIOR RIBS	N/A
LPO 30°	LEFT POSTERIOR RIBS	LEFT POSTERIOR RIBS
RPO 30°	RIGHT POSTERIOR RIBS	RIGHT POSTERIOR RIBS



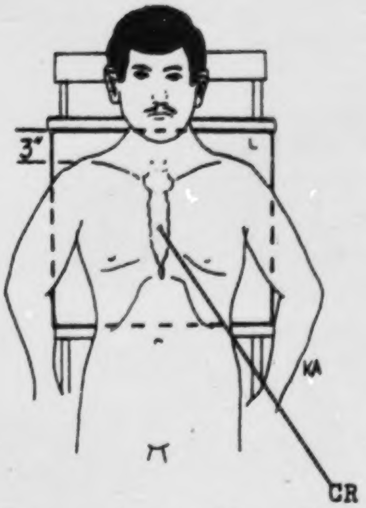






RIBS

Rib Routine: PA Chest, AP OR PA RIBS, OBLIQUE FOR INJURY



Ribs above diaphragm Position AP or PA

PFR: Plane through Acromion processes 3" below the upper film border

Film Rundown: 14 x 17 CW B ID: Above either shoulder

CR: Horizontal Perpendicular Cone: Full film coverage

Alignment: Patient upright, Median plane perpendicular and centered to film.

Breathing Technique: Suspended inspiration FFD: 40"

Demonstrates: Ribs above diaphragm and costalvertebral articulations.

Notes: 1. Rib injuries above the diaphragm, use suspended inspiration to lower the diaphragm.

2. The patient will remove all clothing and jewelry above the waist.

3. Patient Dress: Male patients remove all clothing above the waist Female patients dressed in a gown after removing clothing from waist up.

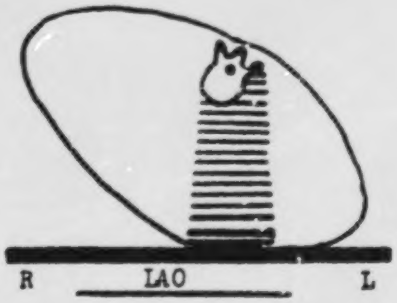
4. AP or PA view is done as a general survey film.

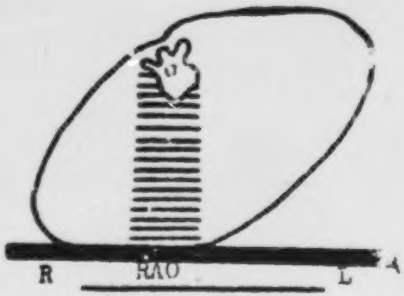
TM 8-280 pp 10-60 Fig 10-54

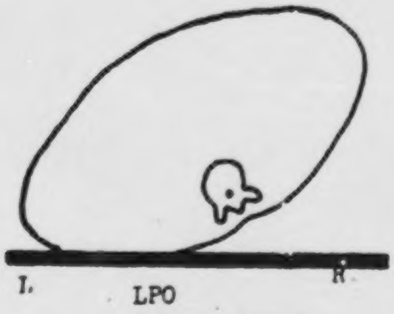
Injured Area 1274 RIBS

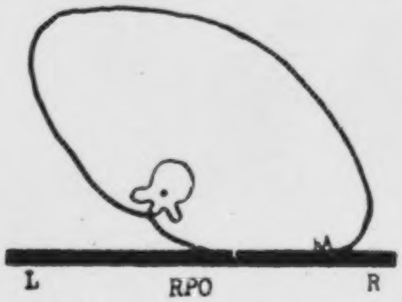
Anterior above: PA Chest, PA Ribs, Oblique for Injury

Posterior above: PA Chest, AP Ribs, Oblique for Injury









Oblique ribs **Positions** Above the diaphragm

PFR: Plane through Acromion processes 3" below the upper border of film holder.

Film Rundown: 14 x 17 CW B ID: Above either shoulder and to correspond with correct side of patient

CR: Horizontal Perpendicular Cone: Full film coverage

Alignment: Trunk centered, coronal plane obliqued 30°, patient upright

Breathing Technique: Suspended Inspiration FFD: 40"

Demonstrates: Ribs at site of injury: RAO-left anterior ribs; LAO- right anterior ribs; RPO-right posterior ribs; LPO-left posterior ribs

Notes: 1. Anterior obliques demonstrate side away from film.

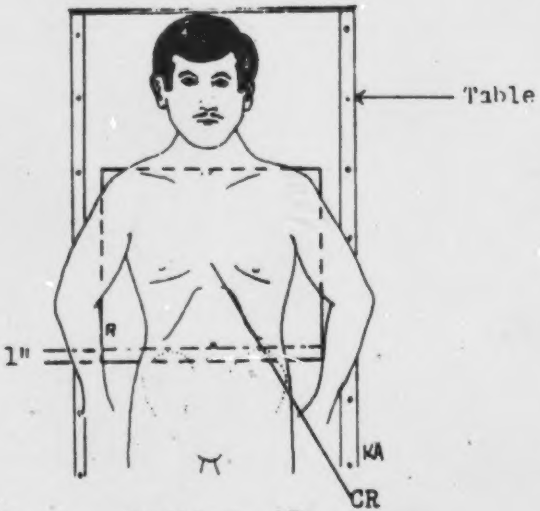
2. Posterior obliques demonstrate side closest to film.

3. A single oblique of side under consideration is taken.

4. Patient dress; Same as chest 1272

RIBS

/ Rib Routine: PA Chest, AP Ribs, Oblique for injury



Ribs Below Diaphragm Position AP

PFR: Iliac crests 1" above the lower film border

Film Rundown: 14 x 17, C W, B ID: Either lateral border

CR: H P Cone: FFC

Alignment: Patient erect, Mediann plane centered

Breathing Technique: Suspended Expiration

Demonstrates: Ribs below diaphragm FFD: 40 "

Notes: 1. Suspended expiration is used to raise the diaphragm

2. The AP view is always done as a general survey film

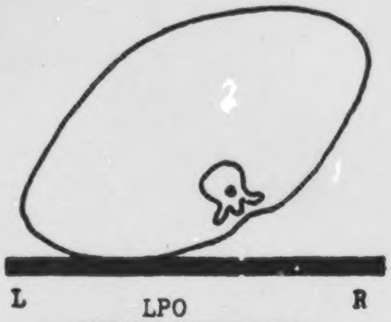
3. Patient's dress; Same as AP or PA

TM8-280 pp 10-59 Fig 10-53

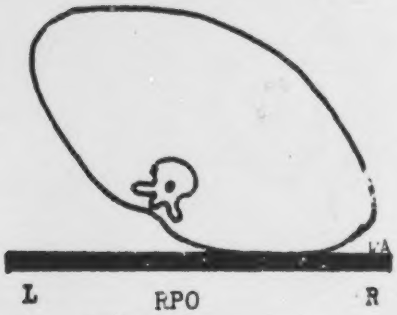
1276

RIBS

Rib Routine: PA Chest, AP Ribs, Oblique for injury



LPO



RPO

Oblique Rib Positions Below the diaphragm

PFR: Plane through Iliac crests 1" above the lower film border

Film Rundown: 14 x 17 CW B ID: Either lateral border to correspond with correct side of patient

CR: Horizontal Perpendicular Cone: Full film coverage

Alignment: Patient erect, Trunk centered, coronal plane rotated 30°

FFD: 40"

Breathing Technique: Suspended expiration

Demonstrates: Site of injury; LPO-Left posterior ribs, RPO-Right posterior ribs

Notes: 1. LPO and RPO demonstrate the posterior ribs that are closest to the film.

2. Patient's dress: Same as chest

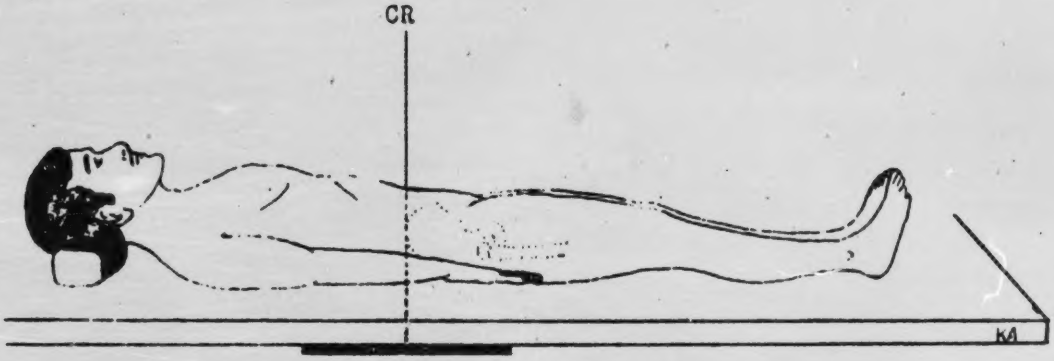
1274

TM8-280 pp 10-60 Fig 10-54

Abdomen

Routine: AP

Additional: Upright



Abdomen (KUB) Position AP

PFR: Plane thru Superior Prominence of Iliac Crest to center of film holder

Film Rundown: 14 x 17, L W, B ID: Either lateral border

CR: V P Cone: FFC

Alignment: Median Plane perpendicular and over center line of table

Breathing Technique: Suspended Expiration FFD: 40 "

Demonstrates: The internal viscera

Notes: 1. This is a survey film of the abdomen from the Symphysis Pubis to the diaphragm. It is frequently called a KUB (kidneys, ureters, and bladder)

2. Patient Dress: Clothing removed and dressed in a gown.

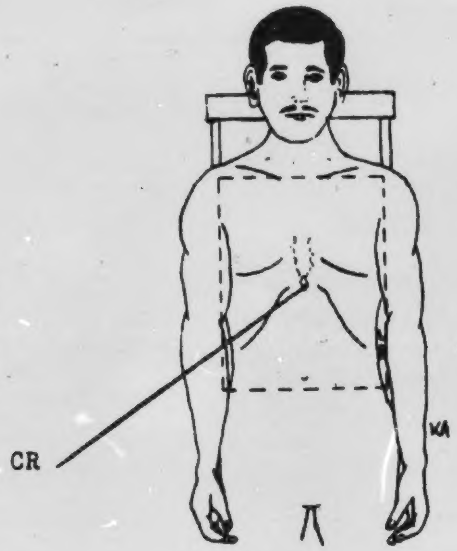
3. Suspended Expiration to control peristaltic motion of the viscera

TM 8-280 pp. 10-64 Figure 10-58

Abdomen

Routine: AP

Additional: Upright



Abdomen Position Upright

PFR: Xiphoid Process to center of film holder

Film Rundown: 14 x 17, L W, B ID: Either lateral border

CR: H P Cone: FFC

Alignment: Median Plane perpendicular and over center line of table

Breathing Technique: Suspended Expiration FFD: 40 "

Demonstrates: Diaphragm, Lower Lungs and internal viscera

Notes: 1. Also aids in demonstrating fluid levels and free air under the diaphragm

2. To demonstrate fluid levels and free air the CR must always be directed Horizontal to the floor.

3. An upright marker must be used with the side letter marker

4. Patient Dress: same as AP

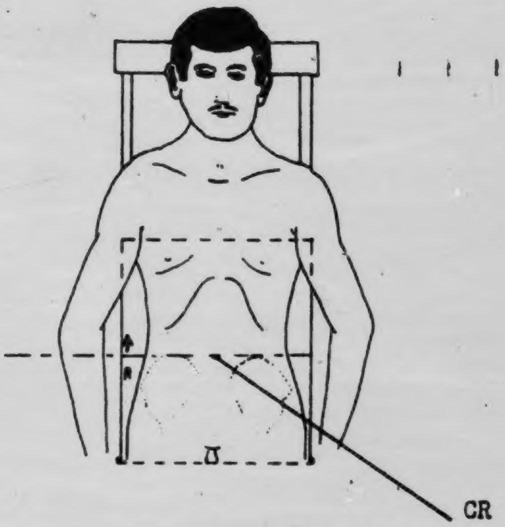
TM 8-280 pp. 10-65 Figure 10-5[illegible]

1279

Abdomen

Routine: AP

Additional: Upright KUB



KUB Position Upright

PFR: Plane thru Superior Prominence of Iliac Crests to center of film holder

Film Rundown: 14 x 17, L W, B ID: Either lateral border

CR: H P Cone: FFC

Alignment: Median Plane perpendicular and over center line of table

Breathing Technique: Suspended Expiration FFD: 40 "

Demonstrates: Kidneys, ureters and urinary bladder

Notes: 1. An upright marker must be used with the side letter marker

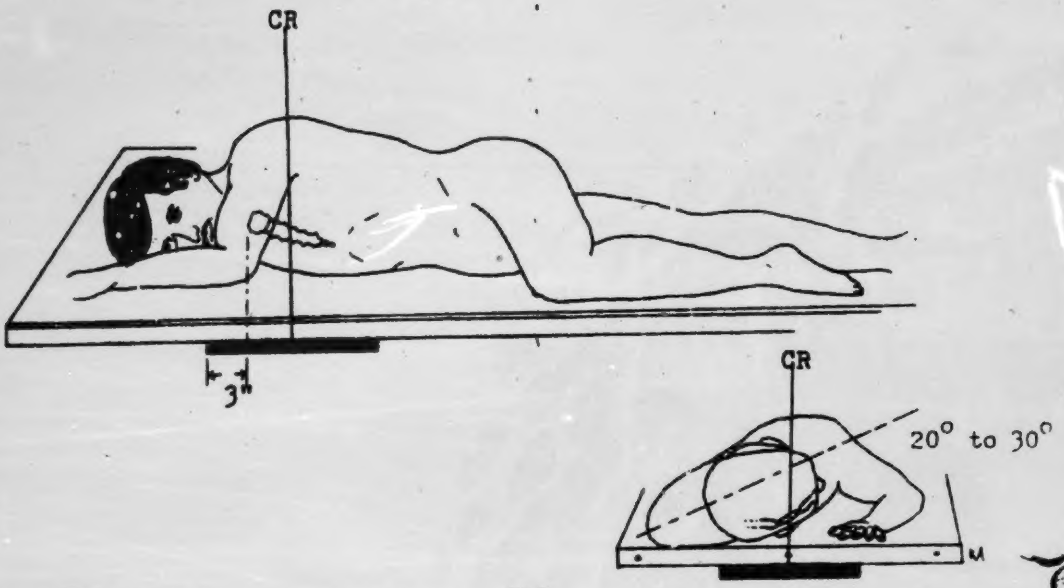
2. Patient Dress: Clothing removed and dressed in a gown

TM 8-280 pp. 10-64 Figure 10-58

1280

Sternum

Routine: RAO and Lateral



Sternum Position RAO

PFR: Manubrial Notch 3" below upper border of film holder

Film Rundown: 10 x 12, L W, B CR: V P Cone: FFC

Alignment: Part Centered, Coronal Plane 20° to 30° obliqued

Breathing Technique: Normal Breathing FFD: 40"

Demonstrates: Entire Sternum and regional soft tissues

Notes: 1. Normal Breathing to blur vascular markings

2. 3 to 5 second exposure time

3. The degree of obliquity will depend on the patients size. A thick person will require less obliquity than a slender person.

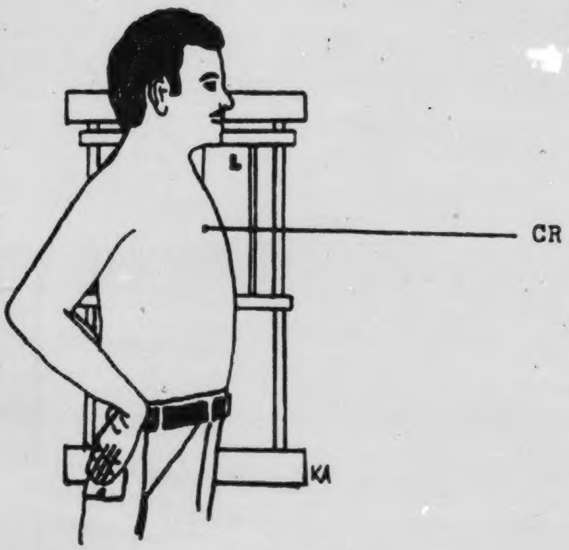
4. Patient Dress: Clothing from waist up removed and dressed in a gown.

5. ID: Either lateral border.

1278

Sternum

Routine: RAO and Lateral



Sternum Position Lateral

PFR: Manubrial notch 3" below upper film border

Film Rundown: 10 x 12, L W, B CR: H P Cone: FFC

Alignment: Median Plane parallel to film with Sternum over the center of film holder.

Breathing Technique: Suspended Inspiration FFD: 40"

Demonstrates: Entire Sternum and regional soft tissues

Notes: 1. Place patients hands, palm out, on back of hips and move shoulders backward.

2. Patient Dress: Clothing from waist up removed and dressed in a gown.

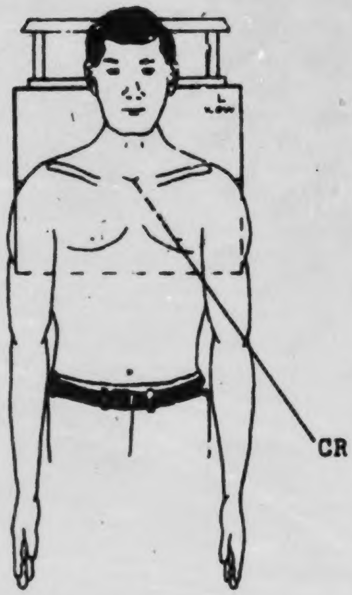
3. ID: Lateral border, anterior to part.

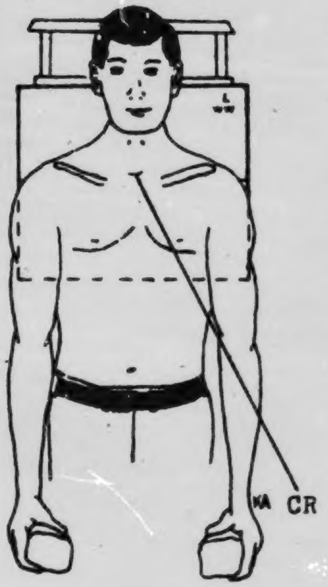
TM 8-280 pp. 10-62 Figure 10-56

1282

Acromioclavicular Joints

Routine: AP with and without weights





Position Without Weights (WOW)

Position With Weights (WW)

PFR: Jugular notch to center of film holder ID: Above shoulder both views

Film Rundown: 14 x 17, C W, NB CR: H P Cone: FFC

Alignment: Median Plane perpendicular to center of film

Breathing Technique: Suspended Respiration FFD: 72 "

Demonstrates: Acromioclavicular Joints

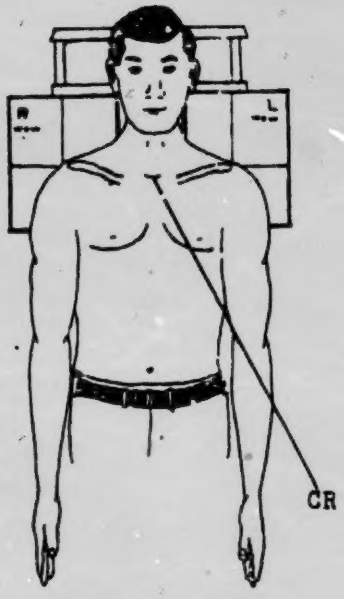
Notes: 1. FFC 72" ; two views; with and without weights to demonstrate acromioclavicular joint separation. 2. ID must include WW (with weights) or WOW (without weights). 3. Patient standing with equal weight on both feet, and holding equal weights in both hands; (usually 5 pounds)

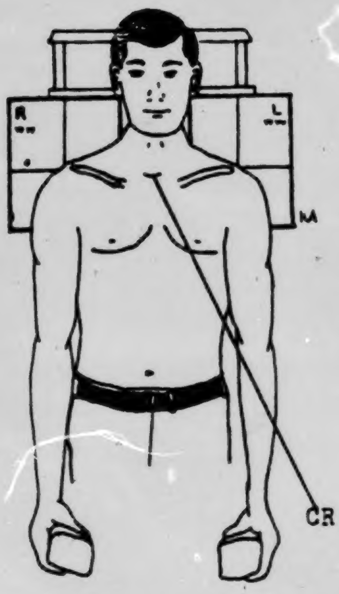
1280

TM 8-280 pp. 10-29 Figure 10-24

Acromioclavicular Joints

Routine: AP with and without weights





Position Without Weights (WOW) Position With Weights (WW)

PFR: Acromion Process to center of each film holder. ID: R and L marker on each film

Film rundown: 8 x 10. L W. NB CR: Horizontal Perpendicular to jugular notch

Alignment: Median Plane perpendicular FFD: 72 "

Breathing Technique: Suspended Respiration

Demonstrates: Acromioclavicular joints

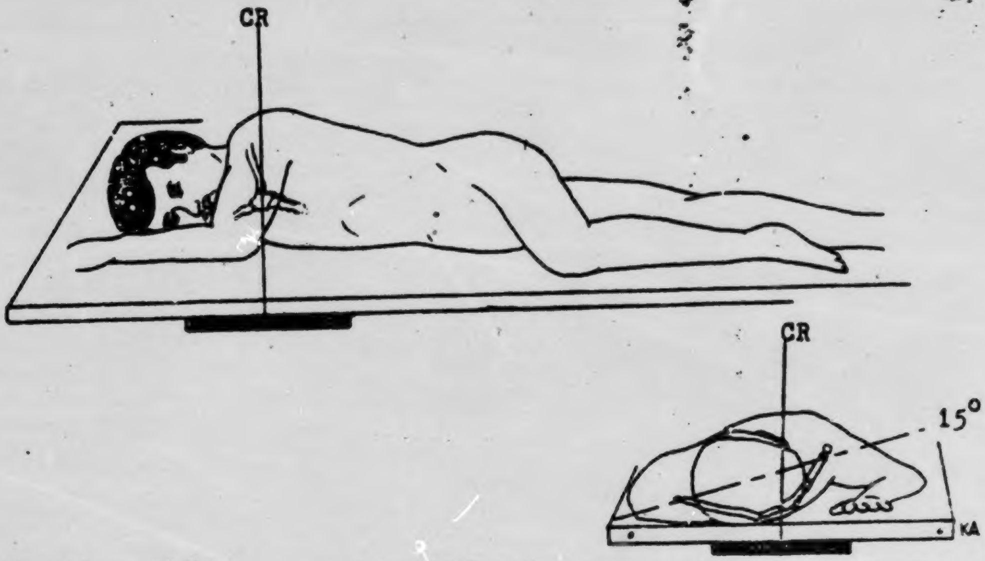
Notes: 1. Separate 8x10's are used to accommodate broad patients where a 14x17 would be too small. 2. The same considerations are used as if using a 14x17 for the procedure. 3. The CR is centered to the jugular notch and both 8x10's exposed simultaneously. 4. ID must include WW or WOW appropriately. 5. Patient standing with equal weight on both feet and holding equal weights in both hands (usually 5 pounds)

TM 8-280 pp. 10-29 Fig. 10-24

1284

Sternoclavicular Joints

Routine: Bilateral Sternoclavicular Joints



Sternoclavicular joints **Position:** RAO, LAO Oblique

PFR: Juglar notch to center of film holder. **ID:** Correct letter marker in conefield

Film Rundown: 8 x 10, L W, B **CR:** V P **Cone:** 6 "

Alignment: Coronal Plane rotated 15° oblique, affected side up

Breathing Technique: Suspended Expiration **FFD:** 40 "

Demonstrates: Sternoclavicular Joints side up

Notes: Sternoclavicular joint may be located 1/2 " lateral to the jugular notch

1282

TM 8-280 pp. 10-63 Figure 10-57

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1285

SFC J. BINKLEY
SFC R. GORDON

*GR 38-520-027-1C
047

X-RAY BRANCH

TO CONSERVE FIGHTING STRENGTH

313-91P10

RADIOGRAPHIC POSITIONING
VOLUME IV
SKULL

MEDICINE AND SURGERY DIVISION
X-RAY BRANCH
FORT SAM HOUSTON, TEXAS 78234

*This general reference supersedes GR 38-520-027-1, 116

1286

TABLE OF CONTENTS

SKULL

PAGE

Objectives 1
Cranial Cross-Sections 2
Skull Positioning Two Way Head Alignment (TWHA) Chart 3
Order of Procedure 4
Positioning of the Skull - Posterior Anterior 5
Positioning of the Skull - Lateral 6
Positioning of the Skull - Chamberlain-Towne 7
Positioning of the skull - Bowen-Hirtz 8
Positioning of the Sinus - Caldwells' 9
Positioning of the Sinus - Waters' 10
Positioning of the Sinus - Lateral 11
Positioning of the Mandible - Posterior Anterior 12
Positioning of the Mandible - Lateral 13
Positioning of the Nose - Lateral 14
Positioning of the Facial Bones - Waters 15
Positioning of the Facial Bones - Lateral 16
Positioning of the Mastoids - Laws' Lateral 17
Positioning of the Mastoids - Hickeys' 18
Positioning of the Temporomandibular Joint (TMJ) Open and Closed 19
Diagram - Cross-Section Petrosa and Inner Ear 20
Positioning of the Petrous Ridge - Stenvers' 21
Positioning of the Petrous Ridge - Arcelins' 22
Positioning of the Petrous Ridge - Mayers' 23
Positioning of the Optic Foramen - Rheses' 24
Positioning of the Zygomatic Arch - Submentalvertical (SMV) 25

1284

1287

OBJECTIVES

1. Identify by name the position and anatomical structures demonstrated.

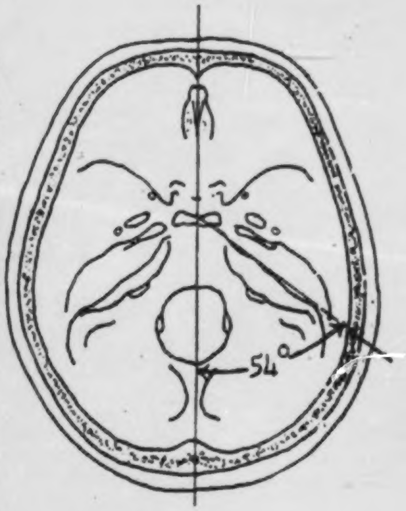
2. Determine the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, immobilization, breathing technique, film identification and captioning necessary to demonstrate the position.

3. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning date which would produce a technically acceptable radiographic position.

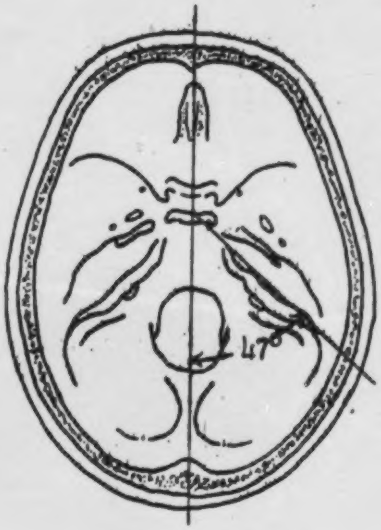
1288

1

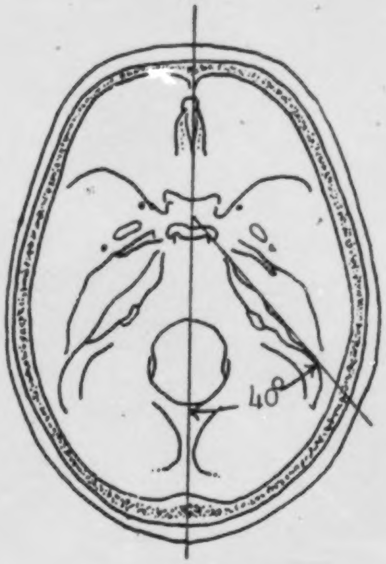
Atypical craniums will, depending upon their shape, require more or less rotation of the head or an increase or decrease in the angulation of the central ray.



BRACHYCEPHALIC
(ATYPICAL)



MESOCEPHALIC
(TYPICAL)



DOLICHOCEPHALIC
(ATYPICAL)

In the brachycephalic head, which is short from front to back, broad from side to side, and shallow from vertex to base, the internal structures are higher with reference to the base line and their long axis are more frontal in position; they form a wider angle with the median sagittal plane.

In the dolichocephalic head. which is long from front to back, narrow from side to side, and deep from vertex to base, the internal structures are lower with reference to the base line and their long axis are less frontal in position; they form a narrower angle with the median sagittal plane.

1286

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SKULL POSITIONING (TWHA) CHART

POSITION	PFR OR CRPR	FRD	CR	CONE FLD	ALIGNMENT
SKULL - PA	Glabella to center	10X12 LW B	VP	FFC	MP $\perp$ OML $\perp$ to film
SKULL - CT	Vertex of skull even with upper film border	10X12 LW B	30°caudad	FFC	MP $\perp$ OML $\perp$ to film
SKULL - LATERAL	Vertex of skull 3" below upper film border	10X12 CW B	VP	FFC	MP $\parallel$ FP to lateral border
SKULL - BOWEN-HIRTZ	Mid-pt of angles of mandible to center of film	10X12 LW B	HP	FFC	MP $\perp$ IOML $\parallel$ to film
SINUS - CALDWELL	Nasion to center	8X10 LW B	15°caudad	6"	MP $\perp$ OML $\perp$ to film
SINUS - WATER'S	Acanthion to center	8X10 LW B	HP	6"	MP $\perp$ OML 37° off film
SINUS - LATERAL	External canthus to center	8X10 LW B	HP	6"	MP $\parallel$ FP to lateral border
MANDIBLE - PA	Mid-pt of angles of mandible to center of film	8X10 LW B	VP	FFC	MP $\perp$ OML $\perp$ to film
MANDIBLE - LATERAL	Mid-pt of body of mandible centered to lower ½ of film	8X10 CW NB	30°cephalic	FFC	MP $\parallel$ Inf. margin body of man. $\parallel$ to lower film border
MASTOID - HICKEY'S	CR to tragus farthest from film projected to center	8X10 LW B	15°caudad	6"	MP 55° IOML $\perp$ to film
MASTOID - LAW'S	CR to tragus nearest film projected to center	8X10 LW B	15°caudad	6"	MP 15° face down, FP $\parallel$ to lateral film border
TMJ'S SCHULLER'S OPEN & CLOSED	CR to tragus nearest film projected to center	8X10 LW B	25°caudad	6"	MP $\parallel$ FP $\parallel$ to lateral border
FACIAL - WATER'S	Acanthion to center	10X12 LW B	VP	FFC	MP $\perp$ OML 37° off film
FACIAL - LATERAL	Mid-pt of AML to center	8X10 LW B	VP	FFC	MP $\parallel$ AML $\parallel$ to lower border
PETROUS RIDGES - STENVER'S	1" ant to tragus nearest film on IOML projected to center	8X10 LW B	12°cephalic	6"	MP 45° IOML $\perp$ to film
PETROUS RIDGES - ARCELIN'S	1" ant 1" sup from tragus farthest projected to center	8X10 LW B	10°caudad	6"	MP 45° IOML $\perp$ to film
PETROUS RIDGES - MAYER'S	Tragus nearest to film projected to center	8X10 LW B	45°caudad	6"	MP 45° IOML $\perp$ to film
ZYGOMATIC ARCHES	Mid-pt of IOML to center	10X12 LW B	HP	FFC	MP $\perp$ IOML $\parallel$ to film
OPTIC FORAMEN - RHESE	Mid-pt of orbit to center	8X10 LW B	VP	6"	MP 53° AML $\perp$ to film

1290

Laboratory - Order of Procedure

I. Control Panel

  a. Measure part

  b. Set technique factors (MA, S, & KVP)

II. Table Factors

  a. FRD & letter marker

NOTE: Put letter marker on film at this time.

  b. Set angle of tube

  c. Set FFD

III. Position Patient

  a. PFR/CRPR

  b. Alignment

NOTE: At times it may be more advantageous to do alignment prior to doing PFR/CRPR.

  c. Align CR to center of film being exposed.

  d. Set proper conefield

NOTE: Check FFD, Letter Marker, and Conefield

IV. Exposure

  a. Verify factors

  b. Give instructions to patient

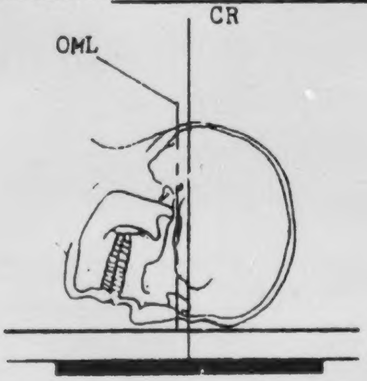
  c. Make exposure

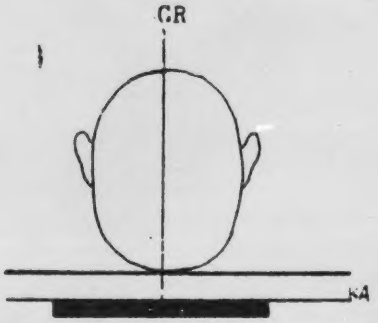
1289

Skull

Routine: Posterior-Anterior, Bi-lateral, and Chamberlain-Towne

Additional: Bowen-Hirtz





Skull Position Posterior-Anterior

PFR: Glabella to center of film holder

Film Rundown: 10 x 12, LW, B ID: Either lateral border

CR VP Cone: FFC

TWHA: Median Plane perpendicular ,and Orbital Meatal Line perpendicular to film.

Breathing Technique: Suspended Respiration FFD: 40"

Demonstrates: Frontal bone, and a general survey of cranium

Notes: 1. Before positioning patient, make sure eye glasses, dentures, hairpins, and earrings have been removed. (for all positions of the skull)

2. On this PA view, the Petrous Ridges completely fill the orbits

3. To free the orbits of the Petrous Ridges angle the CR 23° caudad

4. To place the Petrous Ridges in the lower 1/3 of the orbits, angle the CR 15° caudad

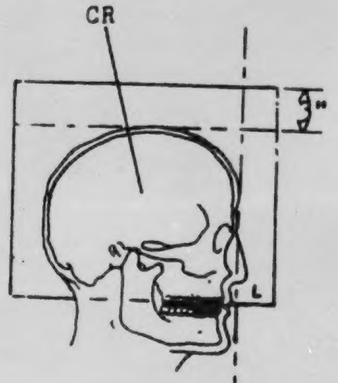
5. Ensure that the patient is in the nose forehead position

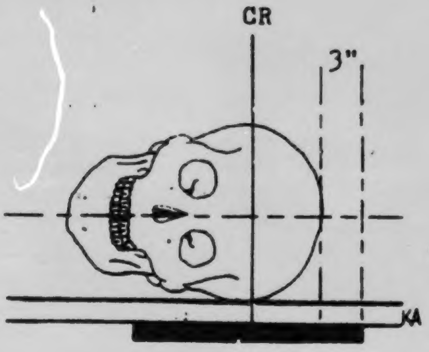
TM 8-280 pp. 10-82 Figure 10-76

Skull

Routine: Posterior-Anterior, Bi-lateral, and Chamberlain-Towne

Additional: Bowen Hirtz





Skull Position Lateral

PFR: Vertex of skull 3" below upper border of film holder

Film Rundown: 10 x 12, CW, B ID: Lateral border anterior to part

CR: V P Cone: FFC

TWHA: Median plane parallel to film, and Facial plane parallel to lateral border of film holder.

Breathing Technique: Suspended Respiration FFD: 40"

Demonstrates: Superimposed halves of the cranium, the sella tursica, the temporal and parietal bones

Notes: 1. Side closest to film is best demonstrated

2. To center the skull, mid-point between EOP and the glabella line over the centerline of the table

3. Before positioning the patient make sure all dentures, eyeglasses etc have been removed (for all positions of the skull)

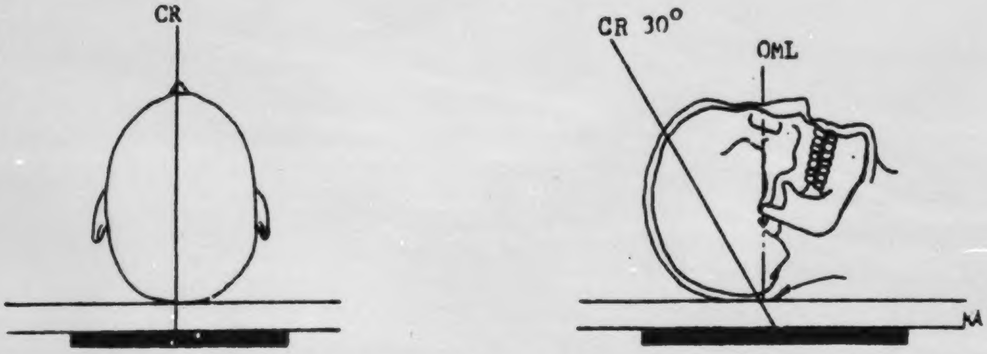
4. Fist may be used for support beneath the chin, to aid in immobilization

TM 8-280 pp. 10-83 Figure 10-77

Skull

Routine: Posterior-Anterior, Bi-lateral, and Chamberlain-Towne

Additional: Bowen-Hirtz



Skull Position Chamberlain-Towne

PFR: Vertex of skull even with upper border of film holder

Film Rundown: 10 x 12, L W, B ID: Either lateral border

CR: 30° Caudad Cone: FFC

Breathing Technique: Suspended Respiration FFD: 40 "

Demonstrates: Occipital bone, foramen magnum, Petrous ridges, and Mastoid air cells

TWHA: Median plane perpendicular, and Orbital meatal line perpendicular to film.

Notes: 1. Before positioning patient remove all dentures, hairpins etc. have been removed for all positions of the skull.

2. When unable to get the OML perpendicular to the film holder, with the patient supine, you should use one of the following variations.
a. Increase angulation of C
b. Do upright with vertica buck

3. Modified Chamberlain-Towne: To demonstrate both condyles of the mandible direct the CR to midpoint of a line connecting the External Auditory Meatus' to center of film holder.

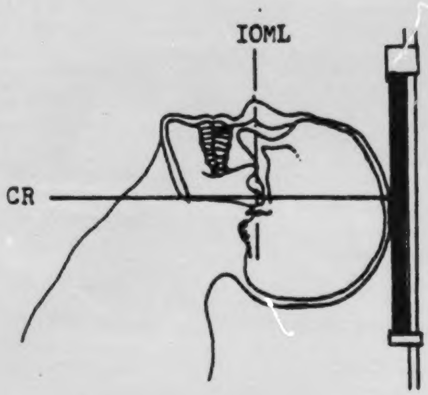
TM 8-280 pp. 10-84 Figure 10-78

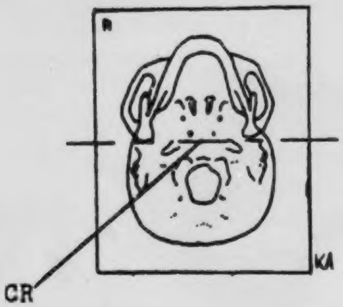
1294

Skull

Routine: Posterior-Anterior, Bi-lateral, and Chamberlain-Towne

Additional: Bowen-Hirtz





Skull Position Bowen-Hirtz

PFR: Midpoint of angles of mandible to center of film holder

Film Rundown: 10 x 12, L W, B ID: Either lateral border

CR: H P Cone FFC

Breathing Technique: Suspended Respiration FFD: 40 "

Demonstrates: Basilar portion of skull, foramen magnum, sphenoid and posterior ethmoid sinuses

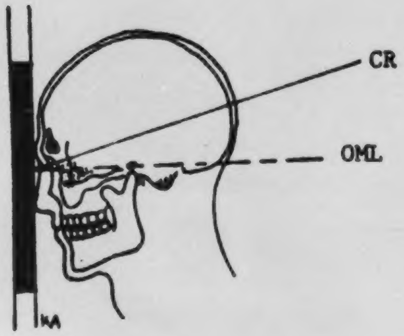
TWHA: Median plane perpendicular, and Infraorbital meatal line parallel to film

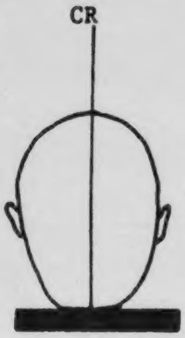
Notes: 1. Patient may be positioned erect (sitting). Patient may also be positioned supine with shoulders buttressed.

2. Before positioning patient, make sure eyeglasses, dentures, etc have been removed. (for all positions of the skull)

Sinus

Routine: Waters, Caldwell, and Lateral





Sinus Position Caldwell

PFR: Nasion to center of film holder

Film Rundown: 8 x 10, L W, B ID: Either lateral border within cone field

CR: 15° Caudad Cone: 6 "

Breathing Technique: Suspended Respiration FFD: 40 "

Demonstrates: Primarily: frontal and anterior ethmoid sinuses
Secondarily: orbits and petrous ridges

TWHA: Median plane perpendicular, and Orbital meatal line perpendicular to film.

Notes: 1. Patient erect to demonstrate fluid levels

2. All artifacts removed to include dentures.

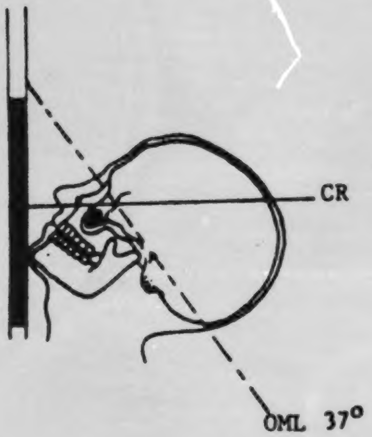
3. Posterior ethmoidal cells are demonstrated best by utilizing a H P CR directed to center of film holder

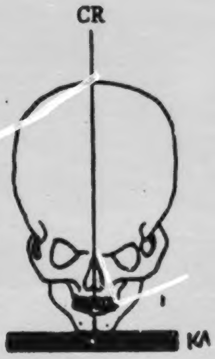
TM 8-280 pp. 10-86 Figure 10-80

1296

Sinus

Routine: Waters, Caldwell, and Lateral





Sinus Position Waters

PFR: Acanthion to center of film holder

Film Rundown: 8 x 10, L W, B ID: Either lateral border within cone field

CR: H P Cone: 6"

Breathing Technique: Suspended Respiration FFD: 40"

Demonstrates: Primarily: maxillary sinus
Secondarily: frontal and ethmoid sinuses, orbits and zygoma

TWHA: Median plane perpendicular, and Orbital meatal line forms an angle of 37° with the film

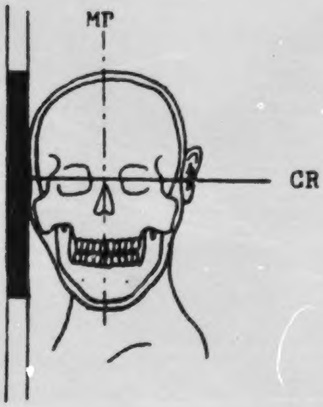
Notes: 1. All sinuses are done erect to show fluid level

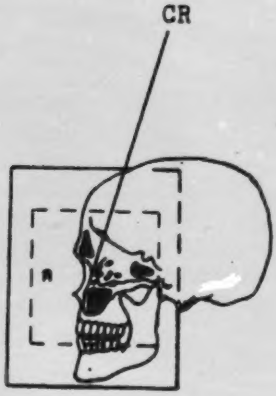
2. All artifacts removed to include dentures.

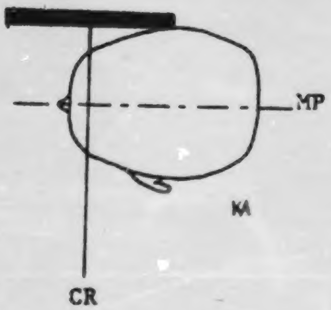
1297

Sinus

Routine: Waters, Caldwell, and Lateral







Sinus Position **Lateral**

PFR: External canthus of the eye to center of film holder

Film Rundown: 8 x 10, L W, B ID: Correct letter marker in conefiel

CR: H P Cone: 6 "

Breathing Technique: Suspended Respiration. FFD: 40 "

Demonstrates: Frontal, ethmoid, sphenoid, and maxillary sinuses

TWHA: Median plane parallel to film, and Facial plane parallel to lateral border of film holder

Notes: 1. All artifacts removed to include dentures

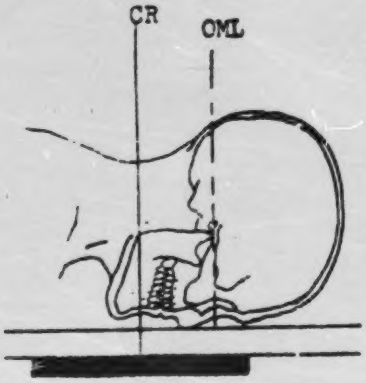
2. Lateral view demonstrates all parnasal sinuses

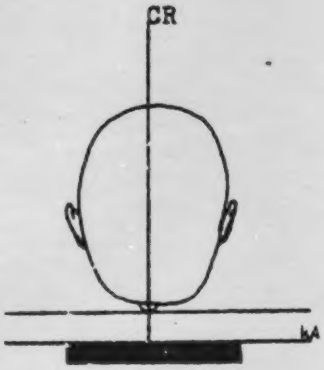
TM 8-280 pp. 10-88 Figure 10-82

1298

Mandible

Routine: PA and Bi-Lateral





Mandible Position PA

PFR: Midpoint of a line connecting angles of mandible to center of film holder ID: Either lateral border

Film Rundown: 8 x 10, L W, B CR: V P Cone: FFC

TWHA Median plane perpendicular, and Orbital meatal line perpendicular to film.

Breathing Technique: Suspended Respiration FFD: 40 "

Demonstrates: Entire mandible

Notes: 1. Nose forehead position

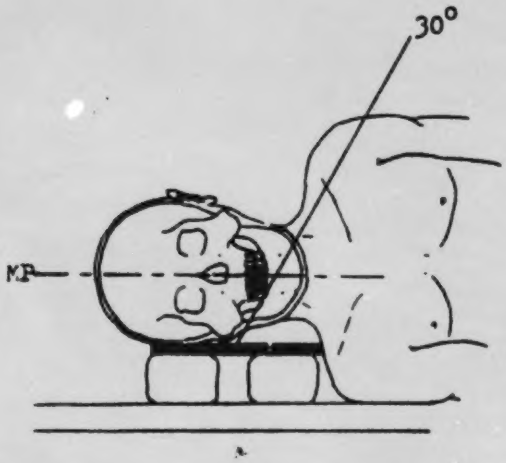
2. Remove all foreign objects from area of mandible, necklaces, dentures etc.

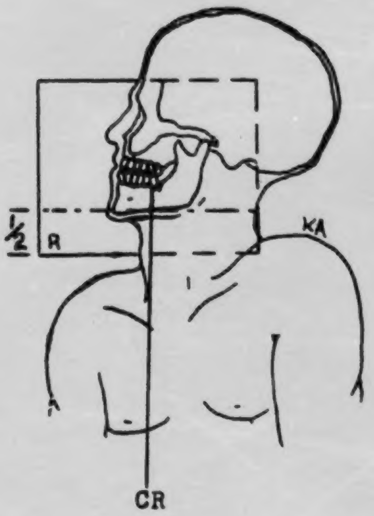
1297

1299

Mandible

Routine: PA and Bi-Lateral





Mandible Position Lateral

PFR: Center of body of mandible to center lower half of film holder

Film Rundown: 8 x 10, C W, NB FFD: 40 " ID: Lateral border anterior to part

CR: 30° Cephalic Cone: FFC

Alignment: Median plane parallel to film and inferior margin of body of mandible parallel with lower film border

Breathing Technique: Suspended Respiration

Demonstrates: Ramus and body of mandible, side closest to film

Notes: 1. In the lateral mandible position, the film should be raised approximately 4" to 6"

2. Remove foreign objects from area of mandible; necklaces, dentures etc.

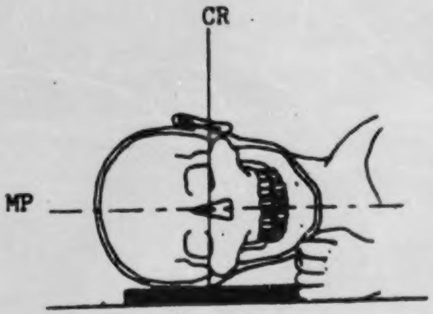
3. Rotate the elevated shoulder rearward, taking care to see that the shoulder is not in the path of the CR

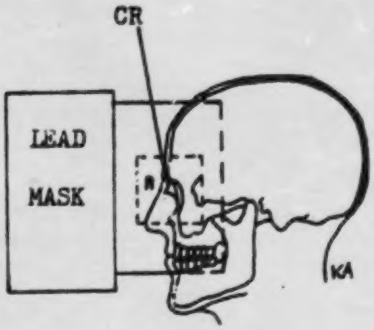
TM 8-280 pp. 10-100 Figure 10-93

1300

Nose

Routine: Bi-Lateral





Nose position: Lateral

PFR: Midpoint of nasal bones to center of film holder

Film rundown: 8 x 10, C W, NB. ID: Correct marker anterior to part

CR: V P Cone: 4"

TWHA: Median plane parallel to film, and Facial plane parallel with the lateral film holder

Breathing Technique: Suspended Respiration FFD: 40"

Demonstrates: Nasal bones in lateral position

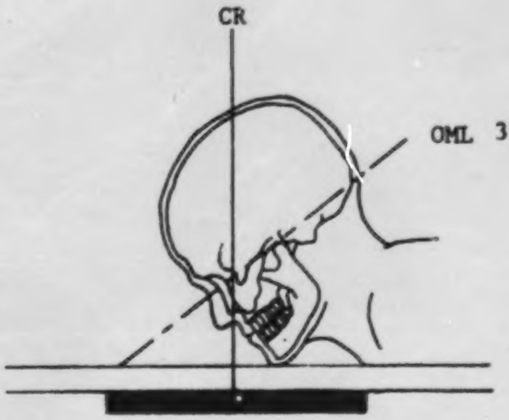
Notes: 1. Ensure markers L and R appear on respective views in conefield

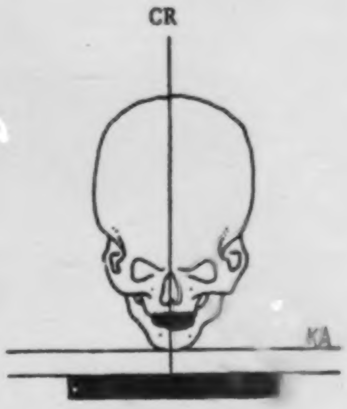
1299

TM 8-280 pp. 10-107 Figure 10-99

Facial Bones

Routine: Waters and Lateral





Facial Bones Position: Waters

PFR: Acanthion to center of film holder

Film Rundown: 10 x 12, L W, B ID: Either lateral border

CR: V P Cone: FFC

TWHA: Median plane perpendicular, and Orbital meatal line forms a 37° angle to film

Breathing Technique: Suspended Respiration FFD: 40 "

Demonstrates: Facial and nasal bones

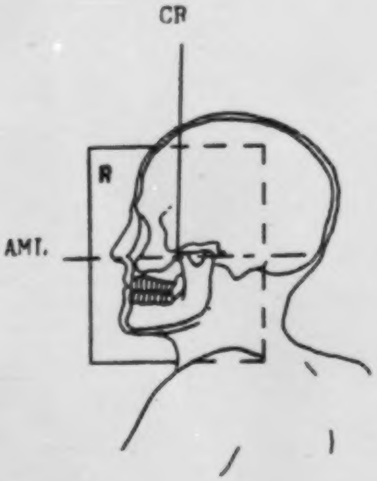
Notes: Artifacts: Before positioning patient, ensure eyeglasses, dentures, hairpins, earrings, etc. have been removed for all skull positions.

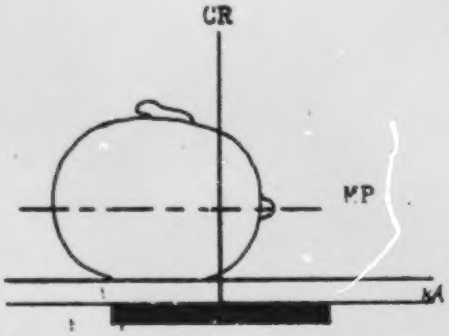
TM 8-280 pp. 10-91 Figure 10-91

1302

Facial Bones

Routine: Waters and Lateral





Facial Bones position: Lateral

PPR: Midpoint of Acanthio-Meatal line to center of film holder

Film rundown: 8 x 10, L W, B ID: Lateral border anterior to part

CR: V P Cone: FFC

TWHA: Median plane parallel to table, and Acanthio-Meatal line parallel to lower film border

Breathing technique: Suspended Respiration FFD: 40 "

Demonstrates: Facial and nasal bones laterally

Notes: Artifacts: Before positioning patient, ensure eyeglasses, dentures, hairpins, earrings, etc. have been removed for all skull positions.

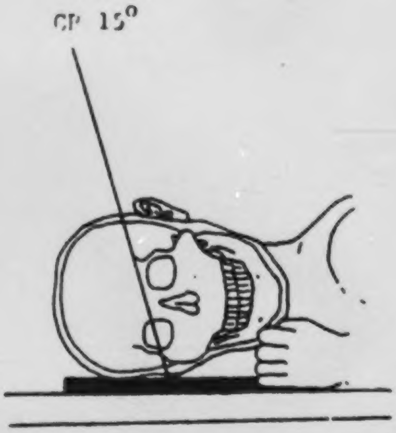
1301

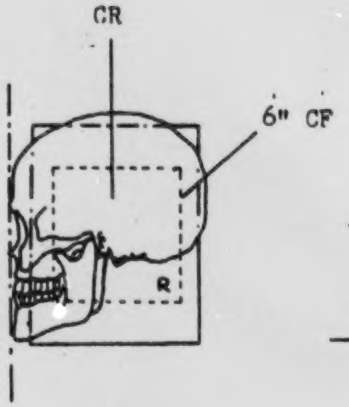
TM 8-280 pp. 10-98 Figure 10-91

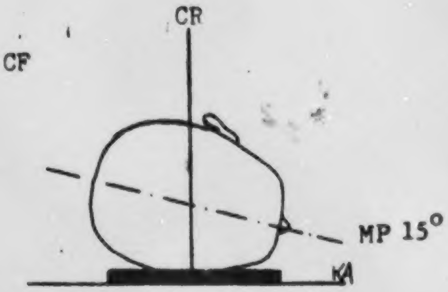
1303

Mastoid

Routine: Law's and Hickey's (Bi-lateral)







Mastoid position: Law's

CRPP: Tragus of side nearest film projected to center of film holder

Film rundown: 8 x 10, L W, B ID: Correct letter marker in conefield

CR: 15° Caudad Cone: 6 "

TWHA: Median plane 15° facedown, facial plane parallel to lateral film border

Breathing Technique: Suspended Respiration FFD: 40 "

Demonstrates: Mastoid air cells

Notes: 1. Side closest to film is under consideration

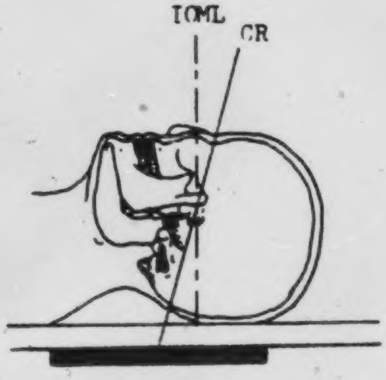
2. Remove all artifacts; earrings, hairpins, dentures etc.

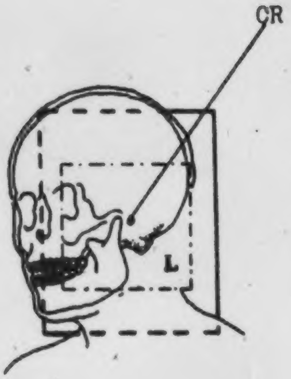
TM 8-280 pp. 10-92 Figure 10-86

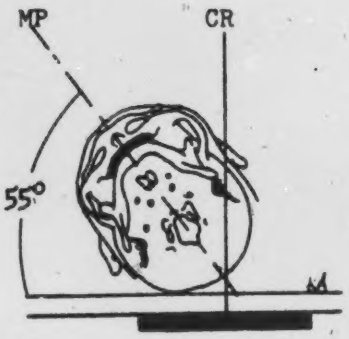
1304

Mastoid

Routine: Law's and Hickeys (Bi-lateral)







Mastoid position: Hickey's

CRPR: Tragus of side farthest from film projected to center of film holder

Film rundown: 8 x 10, L W, B ID: Correct letter marker in conefield

CR: 15° Caudad Cone: 6 "

[illegible]A: Median plane 55° to film. Infraorbital meatal line perpendicular to film

Breathing Technique: Suspended Respiration FFD: 40 "

Demonstrates: Mastoid air cells

Notes: 1. Side up is under consideration

2. Remove all artifacts, earrings, hairpins, dentures etc.

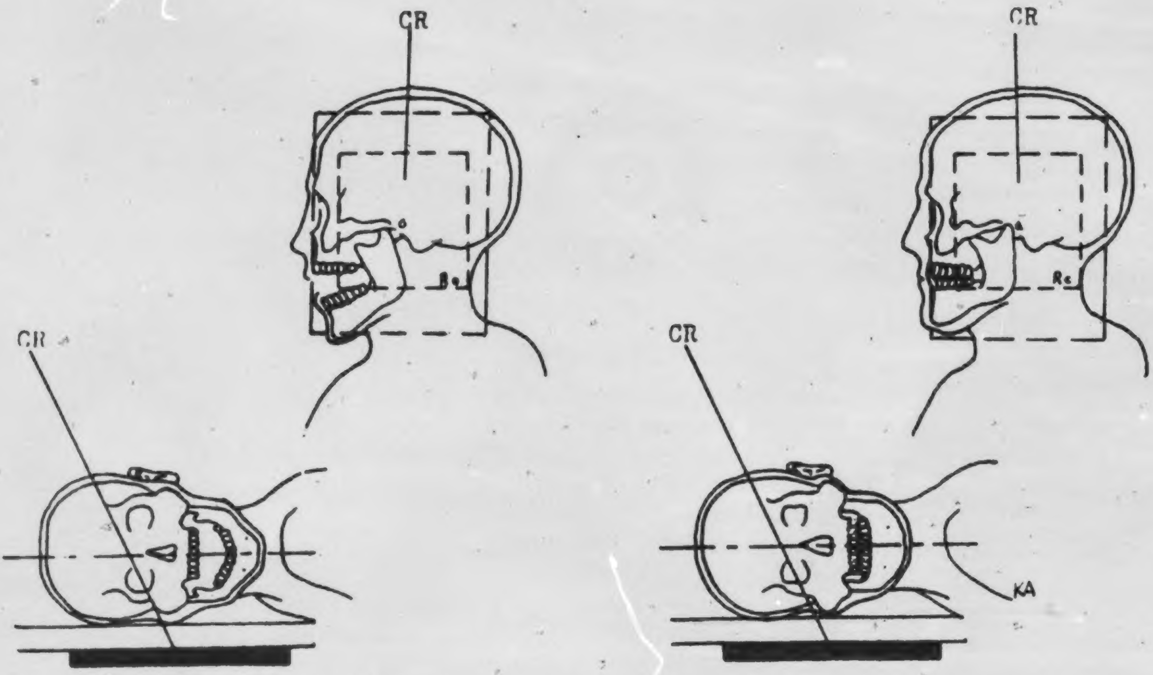
1303

TM 8-280 pp. 10-93 Figure 10-87

1305

Temporomandibular Joint

Routine: Schuller's Bilateral Open and Closed



TMJ position: Schuller's open and closed

CRPR: Tragus of side nearest the film projected to center of film holder

Film rundown: 8 x 10, L W, B ID: Correct letter marker and open (O) or closed (C) in conefield

CR: 25° Caudad Cone: 6 "

TWHA: Median plane parallel to film, and Facial plane parallel to lateral film border

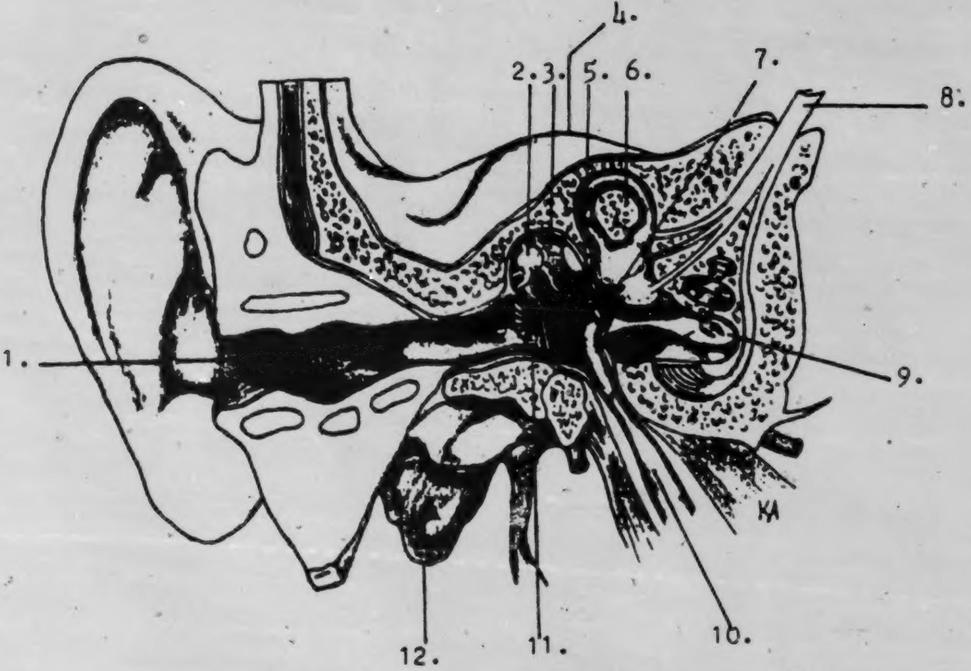
Breathing Technique: Suspended Respiration FFD: 40 "

Demonstrates: Temporomandibular joints

Notes: 1. Side closest to film is under consideration

2. Remove all artifacts; earrings, hairpins, dentures etc.

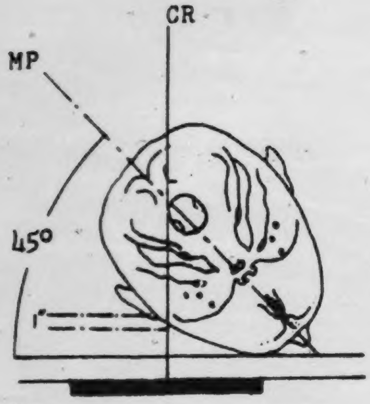
TM 8-280 pp. 10- 92 & 104 Figure 10-86 & 96

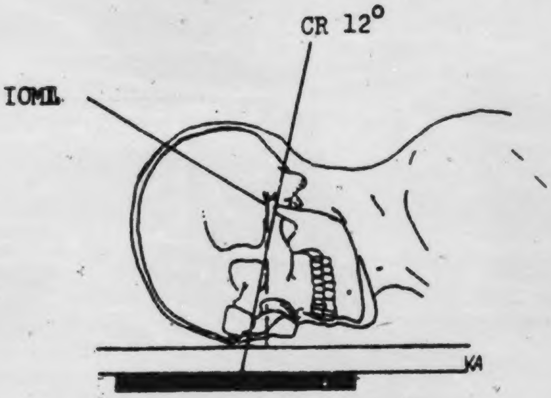


1. External Auditory Meatus
2. Malleus
3. Incus
4. Arcuate Eminence
5. Stapes
6. Semi-circular Canal
7. Oval Window
8. Eighth Nerve
9. Cochlea
10. Eustachian Tube
11. Tympanic Membrane
12. Mastoid Tip

Petrous Ridges

Routine: Bilateral Arcelin's, Stenver's, and Mayer's





Petrous ridge position: Stenver's

CRPR: A point 1" anterior to tragus of side closest to film along Infraorbital meatal line to center of film holder

Film rundown: 8 x 10, L W, B ID: Corresponding letter marker in conefield

CR: 12° Cephalic Cone: 6"

TWHA: Median plane 45° to film,

and Infraorbital meatal line perpendicular to film.

Breathing technique: Suspended Respiration FFD 40"

Demonstrates: Petrous ridge closest to film, Mastoid antrum and internal auditory meatus

Notes: 1. Side down is under consideration

2. Patient prone; three-point landing-- nose, cheek and forehead to table.

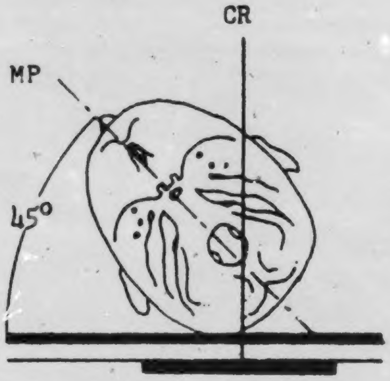
3. Remove artifacts- necklaces, dentures, earrings, hairpins etc.

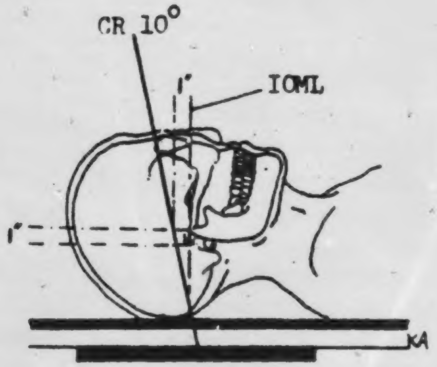
TM 8-280 pp. 10-94 Figure 10-88

1308

Petrous Ridges

Routine: Bilateral Arcelin's, Mayer's and Stenver's





Petrous ridge position: Arcelin's

CRPR: A point 1" anterior and 1" superior to tragus of side up along Infraorbital meatal line projected to center of film holder

Film rundown: 8 x 10, L W , B ID: Corresponding letter marker in conefield

CR: 10° Caudad Cone: 6 "

TWHA: Median plane 45°,

and Infraorbital meatal line perpendicular to film.

Breathing technique: Suspended Respiration FFD: 40 "

Demonstrates: Petrous ridge farthest from film, mastoid antrum, internal auditory meatus

Notes: 1. Patient supine

2. Side up is under consideration

3. Remove artifacts- hairpins, earrings, dentures etc.

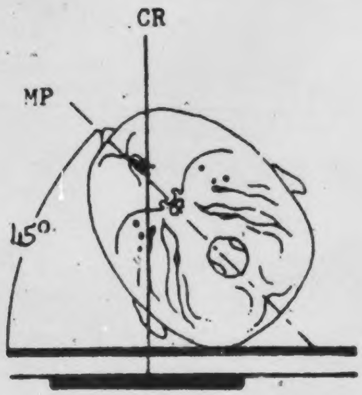
4. Arcelin's is a reverse stenver's

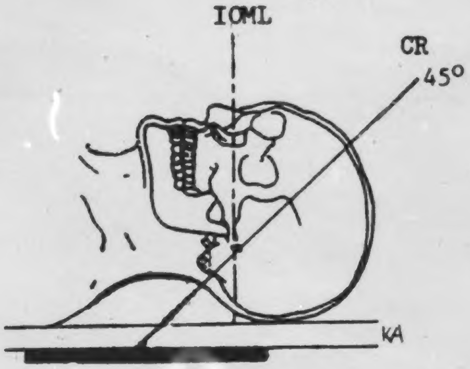
1307

TM 8-280 pp. 10-94 Figure 10-88

Petrous Ridges

Routine: Bilateral Mayer's, Arcelin's and Stenver's





Petrous ridge position: Mayer's

CRPR: Tragus of side closest to film projected to center of film holder

Film rundown: 8 x 10, L W, B ID: Corresponding letter marker in conefield

CR: 45° Caudad Cone: 6 "

T-HA: Median plane 45° to film ,

and Infraorbital meatal line perpendicular to film.

Breathing technique: Suspended Respiration FFD: 40 "

Demonstrates: Petrous ridge in direction of long axis, Mastoid antrum,

internal and external auditory meati .

Notes: 1. Patient supine

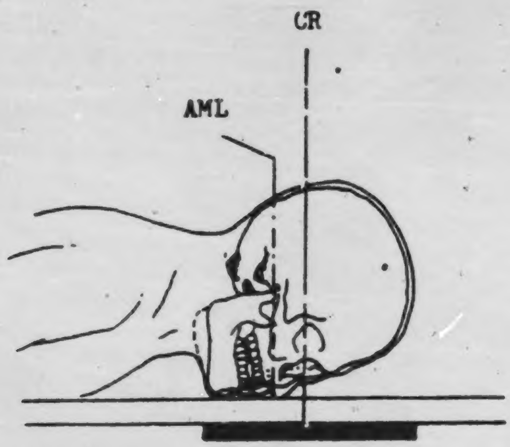
2. Side down is under consideration

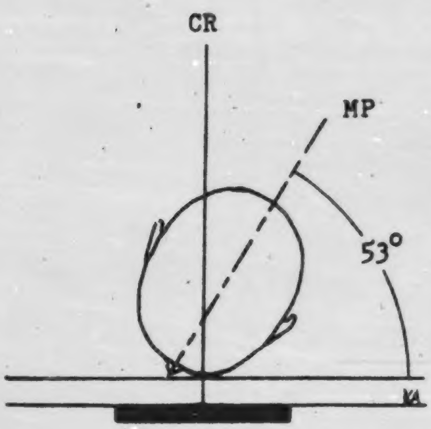
3. Remove all artifacts - hairpins, earrings, eyeglasses, dentures etc.

TM 8-280 pp. 10-95 Figure 10-89

1310

PA (Oblique) Optic Foramen, Rhese Position





PFR: Orbit of side under study centered to film holder

Film rundown: 8 x 10, L W, B ID: Correct letter marker in conefield

CR: V P Cone: 6"

TWHA: Median plane 53° to table, and Acanthiomeatal line perpendicular to film.

Breathing technique: Suspended Respiration FFD: 40 "

Demonstrates: Optic foramen, Posterior ethmoidal and sphenoidal sinuses

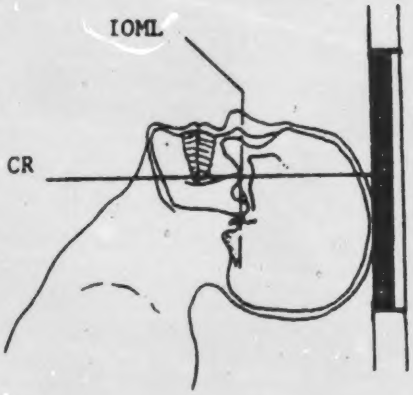
Notes: 1. Three point landing - nose, cheek and chin on table.

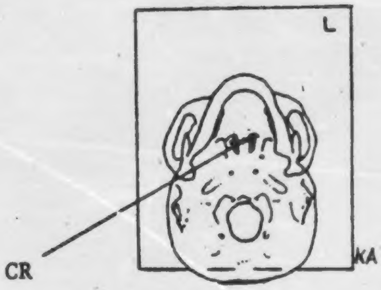
2. Object is to get optic foramen perpendicular to film so CR goes straight down through it.

3. Remove artifacts - hairpins, eyeglasses, dentures, earrings etc.

TM 8-280 pp. 10-91 Figure 10-85

Submentalvertical Zygomatic Arches Position





PFR: Midpoint of Infraorbital meatal line to center of film holder

Film rundown: 10 x 12, L W, B ID: Correct letter marker either lateral border

CR: H P Cone: FFC

TWHA: Median plane perpendicular, and Infraorbital meatal line parallel to film

Breathing technique: Suspended Respiration FFD: 40"

Demonstrates: Zygomatic arches

Notes: 1. Both zygomatic arches demonstrated on same film

2. Remove artifacts - hairpins, earrings, eyeglasses, dentures etc

3. VARIATIONS: see TM 8-280 Ch 10 pg. 106

4. Technical factors reduced from Bowen-Hirtz skull, to avoid overpenetrating the zygomatic arches

TM 8-280 pp. 10-106 Figure 10-98

1312

SECTION IV - ANNEXES

ANNEX D

RADIOGRAPHIC POSITIONING LABORATORY

Peacetime: 125 hours
Mobilization: 125 hours

OBJECTIVE: Given a radiographic examination request and access to standard equipment, determine the proper patient administration and institute the principles of radiologic technology to produce diagnostic quality radiographs. Process completely radiographic film manually and automatically.

Subject and LP No	Lesson Objective	References
Machine Orientation	Demonstrate proper operation of the radiographic machines. In a clinical setting, demonstrate the proper operational procedures of the radiographic machine. In a clinical setting, institute the proper order of procedure and patient handling.	TM 8-280, pp 16-1 thru 16-11. Picker Cat. #6114, 6114A, 6167. GE Manual T-55-35. GE Pam 12802, 12909A, 12526B, 12686B. Product Service Data; Westinghouse Elec Corp.
Laboratory: Upper Extremities	Given a simulated patient and a request slip for the routine or additional views of the upper extremity; hand, forearm, wrist, elbow, humerus (distal, full length), shoulder, S-I and I-S shoulder joint, clavicle and scapula, properly demonstrate, in order of procedure, the technical factors that would produce a technically acceptable radiographic position without aid of references. Practical exercise on crucial objectives. Demonstrate proper operation of the radiographic equipment. In a clinical setting, demonstrate	TM 8-280, pp 10-8 thru 10-28; GR 38-520-027-1, pp 13 thru 40.

1311

Subject and LP No	Lesson Objective	References
	proper medical ethics and patient handling procedures.	
Laboratory: Lower Extremities	Given a simulated patient and a request slip for the routine or additional views of the lower extremity: foot, os calcis, ankle, leg, knee, femur, pelvis, hip, sacrum and coccyx, properly demonstrate, in order of procedure, the technical factors that would produce a technically acceptable radiographic position without aid of references. Practical exercise on crucial objectives. Demonstrate proper operation of the radiographic equipment. In a clinical setting, demonstrate proper medical ethics and patient handling procedures.	TM 8-280, pp 10-30 thru 10-48, 10-78, 10-79; GR 38-520-027-1A, pp 3 thru 31.
Laboratory: Trunk	Given a simulated patient and a request slip for the routine or additional views of the trunk; cervical spine, dorsal spine, lumbar spine, sacroiliac joints, chest, ribs, abdomen, lumbosacral articulation, sternum, sterno-clavicular joints and acromio-clavicular joints, properly demonstrate, in order of procedure, the technical factors that produce a technically acceptable radiographic position without aid of references. Practical exercise on crucial objectives. Demonstrate proper operation of the radiographic equipment. In a clinical setting, demonstrate proper medical ethics and patient handling procedures.	TM 8-280, pp 10-29, 10-52 thru 10-80; GR 38-520-027-1B, pp 3 thru 34.

Subject and LP No	Lesson Objective	References
Laboratory: Cranium	Given a simulated patient and a request slip for the routine or additional views of the skull: skull, sinus, mastoid, petrous, mandible, tempro-mandibular joint, nose, facial, zygomatic arches and Rhese's Optic Foramen, properly demonstrate in order of procedure the technical factors that would produce a technically acceptable radiographic position without aid of references. Practical exercise on crucial objectives. Demonstrate proper operation of the radiographic equipment. In a clinical setting, demonstrate proper medical ethics and patient handling procedures.	TM 8-280, pp 10-81 thru 10-108. GR 520-027-1C, pp 5 - 25.
Laboratory: Esophagus, Stomach Duodenum and Barium Enema	Given a request slip for the routine or additional views of the esophagus, stomach, duodenum and barium enema, properly demonstrate in order of procedure a clinically acceptable radiographic position without aid of references. Demonstrate proper operation of the radiographic equipment with particular attention to: Electrical Protection, Radiation Protection, and user/operator maintenance. In a clinical setting, demonstrate proper medical ethics and patient handling procedures.	TM 8-280, pp 14-1 thru 14-20, para 14-1 thru 14-10.
Laboratory: Gallbladder	Given a request slip for the routine or additional views of the gallbladder, properly demonstrate in order of procedure a clinically acceptable radiographic position without aid of references.	TM 8-280, pp 14-14, para 14-7.

Subject and LP No	Lesson Objective	References
	Demonstrate proper operation of the radiographic equipment with particular attention to: Electrical Protection, Radiation Protection, and user/operator maintenance. In a clinical setting, demonstrate proper medical ethics and patient handling procedures.	
Laboratory: Repeat Positions	Properly position a patient in a manner that will consistently yield a diagnostic radiograph of any routine or any special examination that you have not as yet completed. After practice, to work efficiently, effectively, and safely, with a minimum of discomfort to the patient in producing radiographs of any routine that may be assigned you.	TM 8-280, pp 10-8 thru 10-108: para 10-16, pp 14-1 thru 14-65; para 14-1 thru 14-46.
Laboratory: Make Up Positions	Position a patient in a manner that will consistently yield a diagnostic radiograph of any routine or any special examination that you have not as yet completed. Work efficiently, effectively, and safely with a minimum of discomfort to the patient in producing radiographs of any routine that may be assigned you.	TM 8-280, pp 10-8 thru 10-108; para 10-16; pp 14-1 thru 14-65, para 14-1 thru 14-46.
Laboratory: Spot Film Radiography	Determine the steps in arranging an exposure room for fluoroscopic examinations. Properly precheck the spot film device to insure it is operable prior to bringing the patient into the room.	TM 8-280, pp 12-1 thru 12-9,
Laboratory: Darkroom Operations	Determine the layout of a typical radiographic darkroom. Properly handle and process the flow of incoming exposed radiographs, using time temperature development,	TM 8-280, pp 7-1 thru 7-25, para 7-1

Subject and LP No				Lesson Objective	References
				and automatic processing methods. Locate items of equipment in the darkroom with only safe light illumination. Perform user/operator maintenance for both the manual and automatic darkroom. Correctly mix chemicals for the manual and automatic processor.	

SFC J. L. Binkley

U.S. ARMY MEDICAL FIELD SERVICE SCHOOL *LP 38-520-078
MEDICINE AND SURGERY DIVISION 056

Machine Orientation (5 hours)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom and laboratory

REFERENCES:

TM 8-280, pp 16-1 thru 16-11
Catalog No 6114, 6114A, and 6167. Picker X-Ray Corporation.
Manufacturer's Manual, T-55-35. General Electric Corporation.
Pamphlets (Directions), 12802, 12909A, 12526B, and 12686B. General Electric Company.
Product Service Data. Westinghouse Electric Corporation.

STUDY ASSIGNMENT: None

STUDENT UNIFORM AND EQUIPMENT: Not applicable

TOOLS, EQUIPMENT, AND MATERIALS: Film badge

PERSONNEL: One instructor in classroom. One instructor (MOS 91P2H or 91P4H) per four students in laboratory

INSTRUCTIONAL AIDS: Typical clinical laboratory

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

FIRST HOUR

I. INTRODUCTION (5 min)

A. Opening Statement: During the next hour you will be working in the laboratory with the 50/100 MA Field Unit. After this unit of instruction you, as future X-ray specialists, will have the ability to operate these units and function efficiently in the clinical applicatory phase.

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*This lesson plan supersedes LP 38-520-078, 032

1318

B. Objectives

1. Demonstrate proper operation of the radiographic machines with particular attention to

   a. Electrical precautions.

   b. User/Operator maintenance

2. In a clinical setting demonstrate the proper operational procedures of the radiographic machine with attention to

   a. Order of procedure.

   b. Patient handling.

C. Class Procedure and Lesson Tie-in

None.

II. DEMONSTRATION/EXPLANATION (35 min)

A. 50/100 MA Field Unit

1. Electrical precautions

2. Control panel

   a. KV selection

   b. MA selection

   c. Timer

   d. Voltage compensation

3. Table

   a. Field

   b. Clinical table

4. Tube column

   a. Movements

1317

(1) Linear

(2) Rotational

b. Precautions

5. Tube arm

a. FFD

b. Angulation

NOTE: Energize unit and verify student knowledge of panel by oral quizzing.

6. First echelon maintenance

B. Questions From Students

III. SUMMARY (5 min)

A. Review of Main Points

1. Electrical precautions

2. Control panel

3. Table

4. Tube column

5. Tube arm

6. First echelon maintenance

B. Closing Statement: A workable knowledge of these procedures and facts is of utmost importance to an X-ray specialist.

SECOND HOUR

I. INTRODUCTION (5 min)

A. Opening Statement: The next hour you will be working in the laboratory with the 100 MA Military Field Unit. After this unit of instruction, you, as future X-ray specialists, will have the ability to operate this unit and function efficiently in the clinical applicatory phase.

B. Objectives

1. Demonstrate proper operation of the radiographic machines with particular attention to

   a. Electrical precautions.

   b. User/Operator maintenance.

2. In a clinical setting demonstrate the proper operational procedures of the radiographic machine with attention to

   a. Order of procedure.

   b. Patient handling.

C. Class Procedure and Lesson Tie-in

None.

II. EXPLANATION/DEMONSTRATION (35 min)

A. 100 MA Military Unit

1. Electrical precautions

2. Control panel

   a. MA selection

   b. KV selection

   c. Timers

   d. Voltage compensation

   e. Switches

      (1) Fluoro timer

      (2) Foot switch

      (3) Stereo

      (4) Bucky

3. Table

4. Tube column
    a. Movements
        (1) Linear
        (2) Rotational
    b. Precautions
5. Tube arm
    a. FFD
    b. Angulation
6. First echelon maintenance

NOTE: Energize unit and verify student knowledge of panel by oral quizzing.

B. Questions From Students

III. SUMMARY (5 min)

A. Review of Main Points
1. Electrical precautions
2. Control panel
3. Table
4. Tube column
5. Tube arm
6. First echelon maintenance

B. Closing Statement: A workable knowledge of these procedures and facts is of the utmost importance to the X-ray specialist.

THIRD HOUR

I. INTRODUCTION (5 min)

1322

LP 38-520-078
056

A. Opening Statement: The next hour you will be working in the laboratory with the General Electric 300 MA machine. After this unit of instruction you, as future X-ray specialists, will have the ability to operate this unit and function efficiently in the clinical applicatory phase.

B. Objectives

1. Demonstrate proper operation of the radiographic machines with particular attention to

   a. Electrical precautions.

   b. User/Operator maintenance.

2. In a clinical setting demonstrate the proper operational procedures of the radiographic machine with attention to

   a. Order of procedure.

   b. Patient handling.

C. Class Procedure and Lesson Tie-in

None.

II. EXPLANATION/DEMONSTRATION (35 min)

A. General Electric 300 MA Unit

1. Electrical precautions

2. Control panel

   a. Line on and line off

   b. Line voltage indicator and compensation

   c. KV selection

   d. MA selection

   e. Timers

   f. Phototimer

      (1) Detector

1321

- (2) Master density
- (3) Bucky technique

g. Auxiliaries push buttons

3. Table
    - a. Angulation
    - b. Bucky
4. Tube column
    - a. Movements
        - (1) Linear
        - (2) Rotational
    - b. FFD
    - c. Angulation
5. Spot film device
    - a. Controls
        - (1) Shutter control levers
        - (2) Sequence selector
        - (3) Cassette movement handle and exposure button
        - (4) Pivot lock
    - b. Movements
        - (1) Vertical
        - (2) Longitudinal
    - c. Locks
        - (1) Spot film
        - (2) Carriage

1324

6. First echelon maintenance

B. Questions From Students

III. SUMMARY (5 min)

A. Review of Main Points

1. Electrical precautions

2. Control panel

3. Table

4. Tube column

5. Spot film device

6. First echelon maintenance

B. Closing Statement: A knowledge of these procedures and facts is of the utmost importance to the X-ray specialist.

FOURTH HOUR

I. INTRODUCTION (5 min)

A. Opening Statement: The next hour you will be working in the laboratory with the Westinghouse 500 MA Unit. After this unit of instruction you, as future X-ray specialists, will have the ability to operate this unit and function efficiently in the clinical applicatory phase.

B. Objectives

1. Demonstrate proper operation of the radiographic machines with particular attention to

a. Electrical precautions.

b. User/Operator maintenance.

2. In a clinical setting demonstrate the proper operational procedures of the radiographic machine with attention to

a. Order of procedure.

b. Patient handling.

1323

1325

C. Class Procedure and Lesson Tie-in

None.

II. EXPLANATION/DEMONSTRATION (35 min)

A. Westinghouse 500 MA Unit

1. Electrical precautions

2. Control panel

a. Main line switch

b. Technique selector

(1) Radiographic MA

(2) Spot film absolute time (SFAT)

(3) Spot film phototimed (SFPT)

(4) Cassette changer (CC)

(5) Photofluorography (PF)

(6) Table phototiming w/diaphragm selection (TA windows)

c. KV selection

d. Tube selection

e. Timers

f. Bucky selection

g. Fluorographic settings

(1) MA

(2) KV

(3) Time

h. Tube protection

- (1) Ultra speed
- (2) High KV
- (3) High load
- i. Stereo switch
- j. "Angio" switch
- k. Meters
  - (1) MA--3 scales
  - (2) KV

3. Table
   - a. Angulation
   - b. Bucky
4. Tube column
   - a. Movements
     - (1) Manually
     - (2) Electrically
     - (3) Vertical or horizontal
     - (4) Rotational
   - b. FFD
   - c. Angulation
     - (1) Longitudinal
     - (2) Transversely
   - d. Controls
     - (1) Bucky light
     - (2) Head end--foot end (HE-FE)

        (3) Up - down

        (4) Locks

            (a) Vertical

            (b) Cross table

            (c) Longitudinally

5. Spot film device

    a. Controls

        (1) Spot film device release

        (2) Sequence selector

        (3) Shutter position control

        (4) Shutter control knob

        (5) Cassette advance and park lever

        (6) X-ray exposure and room light switch

        (7) Cassette ejector

        (8) Compression locks

        (9) Operating handle and power assist control

        (10) Table tile--2 speeds

        (11) Longitudinal and centering lock

    b. Movements

        (1) Manually or electrically

        (2) Vertical

        (3) Longitudinal

6. First echelon maintenance

B. Questions From Students

III. SUMMARY (5 min)

A. Review of Main Points

1. Electrical precautions

2. Control panel

3. Table

4. Tube column

5. Spot film device

6. First echelon maintenance

B. Closing Statement: A working knowledge of these procedures and facts is of the utmost importance to the X-ray specialist.

FIFTH HOUR

I. INTRODUCTION (5 min)

A. Opening Statement: The next hour will be used to discuss the various types of older X-ray machines found in the hospital clinics, and to review the use of technique charts. After this unit of instruction you, as future X-ray specialists, will have the ability to operate these units and function efficiently in the clinical applicatory phase.

B. Objectives

1. Demonstrate proper operation of the radiographic machines with particular attention to

   a. Electrical precautions.

   b. User/Operator maintenance.

2. In a clinical setting demonstrate the proper operational procedures of the radiographic machine with attention to

   a. Order of procedure.

   b. Patient handling.

C. Class Procedure and Lesson Tie-in

None.

II. EXPLANATION/DEMONSTRATION (35 min)

A. Typical Hospital Control Panels

1. Electrical precautions
2. 300 MA Autoflex control panel
    a. Main line switch
    b. KV selection
    c. MA selection
    d. Timers
    e. Fluorographic KV and MA
    f. Voltage compensation
3. Picker 300 MA control panel
    a. Main line button
    b. KV selection
    c. MA selection
    d. Timers
        (1) Impulse
        (2) Synchronous
    e. Fluorographic controls
    f. Voltage compensation
4. First echelon maintenance

B. Technique Charts

1. Constant KV
2. Variable MA

1330

C. MAS Chart

D. Questions From Students

III. SUMMARY (5 min)

A. Review of Main Points

1. Electrical precautions
2. 300 MA Autoflex control panel
3. 300 MA Picker control panel
4. User/Operator maintenance.
5. Technique charts
6. MAS chart

B. Closing Statement: A working knowledge of the facts presented to you in the last 5 hours of machine orientation is essential for maximum efficiency in the applicatory phase of this schooling.

1329

1331

SFC J. L. Binkley

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE AND SURGERY
X-RAY BRANCH

*LP 38-520-079
056

Laboratory: Upper Extremities (20 hours)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Laboratory

REFERENCES: TM 8-280, pp 10-8 thru 10-28.

STUDY ASSIGNMENT: Before class review GR 38-520-027-1, pp 13-40.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 issued at beginning of course

TOOLS, EQUIPMENT, AND MATERIALS: Typical Clinical laboratory equipment

PERSONNEL: One instructor (MOS 91P2H or 91P4H) per each four student

INSTRUCTIONAL AIDS: Observation checksheets, AHS Form 69, 136 and clipboard

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Practical Exercise

I. INTRODUCTION (5 min)

A. Opening Statement: During the next 20 hours, you will practice and be graded on the positions as they are demonstrated in GR 38-520-027-1, pp 13-40. This will be done in the laboratory applying the practical aspects of radiography.

B. Objectives

1. Given a simulated patient and a request slip for the routine or additional views of the upper extremity; hand, forearm, wrist, elbow, humerus (distal, full length), shoulder, S-I and I-S shoulder joint, clavicle and scapula, properly demonstrate in order of procedure the technical factors that would produce a technically acceptable radiographic position without aid of references.

2. Practical exercise on crucial objectives

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*This lesson plan supersedes LP 38-520-079 thru 38-520-082, 38-520-094, 032

3 Demonstrate proper operation of the radiographic equipment with particular attention to:

   a. Electrical protection.

   b. Radiation protection.

   c. User/operator maintenance.

4 In a clinical setting demonstrate proper medical ethics and patient handling procedures.

C. Class Procedure and Lesson Tie-in

   1. Student will act as technician and/or patient during laboratory procedures.

   2. Student will use the positions as demonstrated in the classroom.

II. APPLICATION (1165 min)

A. Preliminary Requirements

   1. Assign machine numbers

   2. Designate working pairs

   3. Instructions prior to crucial/practice

      a. Wear film badge

      b. Energize unit

B. Directions to Students

   1. Observe safety precautions

   2. Follow order of procedure guide

   3. Carry each position to completion

   4. Maintain silence as a patient

C. Arrangement of Students and Materials

1. Student teams
    a. One pair for each x-ray unit
    b. Alternate as technician and patient
2. X-ray exposure facilities
    a. One complete diagnostic assembly for each student pair
    b. Modified tubeheads

NOTE: Instructor insures that machines have been defused to prevent live radiation emitting from tube.

    c. Typical darkroom

D. General Plan for Conduct of Crucial/Exercise

1. Student technician/patient roles
    a. First student working two periods
    b. Second student working two periods
2. Request slip assignments
3. Step-by-step application of procedure
4. Immediate reteach of errors after each position
5. Final critique at end of lab period

E. Request Slip Assignment for this Crucial/Exercise

1. Hand (GR 38-520-027-., pp 13-15)
2. Wrist (GR 38-520-027-1, pp 17-20)
3. Forearm (GR 38-520-027-1, pp 21-24)
4. Elbow (GR 38-520-027-1, pp 25-27)
5. Humerus (GR 38-520-027-1, pp 28-32)

6. Shoulder (GR 38-520-027-1, pp 33-34)

7. S-I, I-S Shoulder Joint (GR 38-520-027-1, pp 35-36)

8. Clavicle (GR 38-520-027-1, pp 37-38)

9. Scapula (GR 38-520-027-1, pp 39-40)

F. User/Operator Maintenance

III. REVIEW (30 min)

A. Questions From Students

1. Student requirements

2. Directions to students

3. Arrangement of students and materials

4. Conduct of crucial/exercise

5. Upper extremity assignments

6. Room maintenance

B. Closing Statement: These last 20 hours gave you a good working knowledge of your future duties as X-Ray Specialist. With this in mind, always strive to achieve perfection in positioning and aligning the patient, and you will avoid repeat films and excess radiation to the patient.

SFC J. Binkley

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE & SURGERY
X-RAY BRANCH

*LP 38-520-083
056

Laboratory: Lower Extremities (25 hours)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Laboratory

REFERENCES: TM 8-280, pp 10-30 thru 10-48; 10-78 and 10-79

STUDY ASSIGNMENT: Before class review GR 38-520-027-1A, pp 3 thru 31

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 issued at beginning of course

TOOLS, EQUIPMENT, AND MATERIALS: Typical clinical laboratory equipment

PERSONNEL: One instructor (MOS 91P2H or 91P4H) per each four students

INSTRUCTIONAL AIDS: Observation checksheets, AHS Form 69, 136 and clipboard

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Practical Exercise

I. INTRODUCTION (5 min)

A. Opening Statement: During the next 25 hours you will practice and be graded on the positions as they are demonstrated in GR 38-520-027-1A, pp 10-30 thru 10-48; 10-78 and 10-79. This will be done in the laboratory applying the practical aspects of radiography.

B. Objectives

1. Given a simulated patient and a request slip for the routine or additional views of the lower extremity: foot, os calcis, ankle, leg, knee, femur, pelvis, hip, sacrum and coccyx, properly demonstrate, in order of procedure, the technical factors that would produce a technically acceptable radiographic position without aid of references.

2. Practical exercise on crucial objectives

---

*This lesson plan supersedes LP 38-520-083 thru 086, 032; LP 38-520-096, 100 and LP 38-520-105, 38-520-106, 032

3. Demonstrate proper operation of the radiographic equipment with particular attention to:

   a. Electrical protection

   b. Radiation protection

   c. User/operator maintenance

4. In a clinical setting demonstrate proper medical ethics and patient handling procedures.

C. Class Procedure and Lesson Tie-in

1. Student will act as technician and/or patient during laboratory procedures.

2. Student will use the positions as demonstrated in the classroom.

II. APPLICATION (1465 min)

A. Preliminary Requirements

1. Assign machine numbers

2. Designate working pairs

3. Instructions prior to crucial/practice

   a. Wear film badge

   b. Energize unit

B. Directions to Students

1. Observe safety precautions

2. Follow order of procedure guide

3. Carry each position to completion

4. Maintain silence as a patient

C. Arrangement of Students and Materials

1. Student teams
    - a. One pair for each x-ray unit
    - b. Alternate as technician and patient
2. X-ray exposure facilities
    - a. One complete diagnostic assembly for each student pair
    - b. Modified tubeheads

NOTE: Instructor insures that machines have been defused to prevent live radiation emitting from the tube.

- c. Typical darkroom

D. General Plan for Conduct of Crucial/Exercise

1. Student-technician/patient roles
    - a. First student working two periods
    - b. Second student working two periods
2. Request slip assignments
3. Step-by-step application of procedure
4. Immediate reteach of errors after each position
5. Final critique at end of laboratory period

E. Request Slip Assignment for this Crucial/Exercise

1. Foot (GR 38-520-027-1A, pp 3-5)
2. Os Calcis (GR 38-520-027-1A, pp 6-7)
3. Ankle (GR 38-520-027-1A, pp 8-10)
4. Leg (GR 38-520-027-1A, pp 11-12)
5. Knee (GR 38-520-027-1A, pp 13-19)

1338

6. Femur (GR 38-520-027-1A, pp 20-23)
7. Pelvis (GR 38-520-027-1A, pp 24-25)
8. Hip (GR 38-520-027-1A, pp 26-27)
9. Sacrum (GR 38-520-027-1A, pp 28-29)
10. Coccyx (GR 38-520-027-1A, pp 30-31)

F. User/operator Maintenance

III. REVIEW (30 min)

A. Questions From Students

1. Student requirements
2. Directions to students
3. Arrangement of students and materials
4. Conduct of crucial/exercise
5. Lower extremity assignments
6. Room maintenance

B. Closing Statement: These last 25 hours gave you a good working knowledge of your future duties as X-Ray Specialists. With this in mind, always strive to achieve perfection in positioning and aligning the patient, and you will avoid repeat films and excess radiation to the patient.

1337

SFC J. Binkley

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE & SURGERY
OPERATING ROOM BRANCH

*LP 38-520-087
056

Laboratory: Trunk (29 hours)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Laboratory

REFERENCES: TM 8-280, p 10-29; 10-52 thru 10-80

STUDY ASSIGNMENT: Before class review GR 38-520-027-1B, p 3-34.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 issued at beginning of course.

TOOLS, EQUIPMENT, AND MATERIALS: Typical clinical laboratory equipment

PERSONNEL: One instructor (MOS 91P2H or 91P4H) per each four students

INSTRUCTIONAL AIDS: Observation checksheets, AHS Form 69, 136, and clipboard

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Practical Exercise

I. INTRODUCTION (5 min)

A. Opening Statement: During the next 29 hours, you will practice and be graded on the positions as they are demonstrated in GR 38-520-027-1B, p 10-29, 10-52 thru 10-80. This will be done in the laboratory applying the practical aspects of radiography.

B. Objectives

1. Given a simulated patient and a request slip for the routine or additional views of the trunk; cervical spine, dorsal spine, lumbar spine, sacroiliac joints, chest, ribs, abdomen, lumbosacral articulation, sternum, sterno-clavicular joints and acromio-clavicular joints, properly demonstrate, in order of procedure, the technical factors that produce a technically acceptable radiographic position without aid of references.

2. Practical exercise on crucial objectives

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*This lesson plan supersedes LP 38-520-087, 097; LP 38-520-088 thru 091,032; LP 38-520-095, 100; LP 38-520-104, 032; LP 38-520-107 and 108, 032.

1340

3. Demonstrate proper operation of the radiographic equipment with particular attention to:
    a. Electrical protection
    b. Radiation protection
    c. User/operator maintenance
4. In a clinical setting demonstrate proper medical ethics and patient handling procedures.

C. Class Procedure and Lesson Tie-in

1. Student will act as technician and/or patient during laboratory procedures.
2. Student will use the positions as demonstrated in the classroom.

II. APPLICATION (1705 min)

A. Preliminary Requirements

1. Assign machine numbers
2. Designate working pairs
3. Instructions prior to crucial/practice
    a. Wear film badge
    b. Energize unit

B. Directions to Students

1. Observe safety precautions
2. Follow order of procedure guide
3. Carry each position to completion
4. Maintain silence as a patient

1339

C. Arrangement of Students and Materials

1. Student teams

   a. One pair for each x-ray unit

   b. Alternate as technician and patient

2. X-ray exposure facilities

   a. One complete diagnostic assembly for each student pair

   b. Modified tubeheads

NOTE: Instructor insures that machines have been defused to prevent live radiation emitting from the tube.

   c. Typical darkroom

D. General Plan for Conduct of Crucial/Exercise

1. Student-technician/patient roles

   a. First student working two periods

   b. Second student working two periods

2. Request slip assignments

3. Step-by-step application of procedure

4. Immediate reteach of errors after each position

5. Final critique at end of laboratory period

E. Request Slip Assignment for this Crucial/Exercise

1. Cervical Spine (GR 38-520-027-1B, p 3-8).

2. Dorsal Spine (GR 38-520-027-1B, p 9-11).

3. Lumbar SPINE (GR 38-520-027-1B, p 12-14).

4. Lumbosacral Articulation (GR 38-520-027-1B, p 15-16).

5. Sacroiliac joints (GR 38-520-027-1B, p 17).

6. Chest (GR 38-520-027-1B, p 18-21).

7. Ribs (GR 38-520-027-1B, p 23-26)

8. Abdomen (GR 38-520-027-1B, p 27-29)

9. Sternum (GR 38-520-027-1B, p 30-31)

10. Acromio-clavicular joints (GR 38-520-027-1B, p 32-33)

11. Sterno-clavicular joints (GR 38-520-027-1B, p 34)

F. User/Operator Maintenance

III. REVIEW (30 min)

A. Questions From Students

1. Student requirements

2. Direction to students

3. Arrangement of students and materials

4. Conduct of crucial/exercise

5. Trunk assignments

6. Room maintenance

B. Closing Statement: These last 29 hours gave you a good working knowledge of your future duties as X-Ray Specialists. With this in mind always strive to achieve perfection in positioning and aligning the patient, and you will avoid repeat films and excess radiation to the patient.

SFC JIMMIE BINKLEY
*LP 38-520-092
056

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE & SURGERY
X-RAY BRANCH

Laboratory: Cranium (25 hours)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Laboratory

REFERENCES: TM 8-280, p 10-81 thru 10-108

STUDY ASSIGNMENT: Before class review GR 38-520-027-1C, p 5-25.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280 issued at beginning of course.

TOOLS, EQUIPMENT, AND MATERIALS: Typical clinical laboratory equipment.

PERSONNEL: One instructor (MOS 91P2H or 91P4H) per each four students.

INSTRUCTIONAL AIDS: Observation checksheets, AHS Form 69, 136 and clipboard.

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Practical Exercise

I. INTRODUCTION (5 min)

A. Opening Statement: During the next 25 hours, you will practice and be graded on the positions as they are demonstrated in GR 38-520-027-1C, p 5-25. This will be done in the laboratory applying the practical aspects of radiography.

B. Objectives

1. Given a simulated patient and a request slip for the routine or additional views of the skull: skull, sinus, mastoid, petrous, mandible, tempro-mandibular joint, nose, facial, zygomatic arches and Rhese's Optic Foramen, properly demonstrate in order of procedure, the technical factors that would produce a technically acceptable radiographic position without aid of references.

2. Practical exercise on crucial objectives

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*This lesson plan supersedes LP 38-520-092 thru 093, 097; LP 38-520-100 thru 103, 032; and LP 38-520-099, 090

- Demonstrate proper operation of the radiographic equipment with particular attention to:
    - a. Electrical protection
    - b. Radiation protection
    - c. User/operator maintenance
- In a clinical setting demonstrate proper medical ethics and patient handling procedures.

C. Class Procedure and Lesson Tie-in

1. Student will act as technician and/or patient during laboratory procedures.
2. Student will use the positions as demonstrated in the classroom.

II. APPLICATION (1465 min)

A. Preliminary Requirements

1. Assign machine numbers
2. Designate working pairs
3. Instructions prior to crucial/practice
    - a. Wear film badge
    - b. Energize unit

B. Directions to Students

1. Observe safety precautions
2. Follow order of procedure guide
3. Carry each position to completion
4. Maintain silence as a patient

C. Arrangement of Students and Materials

1. Student teams
    - a. One pair for each X-ray unit

  - b. Alternate as technician and patient

- 2. X-ray exposure facilities
  - a. One complete diagnostic assembly for each student pair
  - b. Modified tubeheads

NOTE: Instructor insure that machines have been defused to prevent live radiation emitting from the tube.

  - c. Typical darkroom

D. General Plan for Conduct or Crucial/Exercise

- 1. Student-technician/patient roles
  - a. First student working two periods
  - b. Second student working two periods
- 2. Request slip assignments
- 3. Step-by-step application of procedure
- 4. Immediate/reteach of errors after each position
- 5. Final critique at end of laboratory period

E. Request Slip Assignment for this Crucial/Exercise

- 1. Skull (GR 38-520-027-1C, pp 5-8)
- 2. Sinus (GR 38-520-027-1C, pp 9-11)
- 3. Mandible (GR 38-520-027-1C, pp 12-13)
- 4. Nose (GR 38-520-027-1C, pp 14)
- 5. Facial (GR 38-520-027-1C, pp 15-16)
- 6. Mastoid (GR 38-520-027-1C, pp 17-18)
- 7. TMJ's (GR 38-520-027-1C, pp 19)
- 8. Petrous (GR 38-520-027-1C, pp 21-23)
- 9. Rhese's Optic Foramen (GR 38-520-027-1C, pp24)

1346

10. Zygomatic Arches (GR 38-520-027-1C, pp 25)

F. User/Operator Maintenance

III. REVIEW (30 min)

A. Questions From Students

1. Student requirements
2. Direction to students
3. Arrangement of students and materials
4. Conduct of crucial/exercise
5. Cranium assignments
6. Room maintenance

B. Closing Statement: These last 25 hours gave you a good working knowledge of your future duties as X-ray Specialists. With this in mind, always strive to achieve perfection in positioning and aligning the patient, and you will avoid repeat films and excess radiation to the patient.

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE & SURGERY
X-RAY BRANCH

*LP 38-520-097
036

Laboratory: Esophagus, Stomach, Duodenum, and Barium Enema (4 hours).

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Laboratory

REFERENCES: TM 8-280

STUDY ASSIGNMENT: Before Class Review TM 8-280, pp 14-1 to 14-13.

STUDENT UNIFORM AND EQUIPMENT: Not applicable

TOOLS, EQUIPMENT, AND MATERIALS: Typical clinical laboratory; X-Ray request form SF 519A

PERSONNEL: One instructor (MOS 91P2H or 91P4H X-Ray Branch) per each four students

INSTRUCTIONAL AIDS: Observation checksheets; clipboards, Radiographic illuminators

TROOP REQUIREMENTS: None

TYPE OF INSTRUCTION: Practical exercise (4 hours)

I. INTRODUCTION (2 min)

A. Opening Statement: During the next 4 hours you will practice the positions that have been demonstrated, to examine the digestive system.

B. Objectives

1. Given a request slip for the routine or additional views of the esophagus, stomach, duodenum and barium enema, properly demonstrate in order of procedure a clinically acceptable radiographic position without aid of references.

2. Demonstrate proper operation of the radiographic equipment with particular attention to: Electricl protection, Radiation protection, and user/operator maintenance.

3. In a clinical setting demonstrate proper medical ethics and patient handling procedures.

This Lesson Plan Supersedes LP 38-520-097, 124.

- a. Electrical protection
- b. Radiation protection
- c. First echelon maintenance

C. Class Procedure and Lesson Tie-in

None

II. APPLICATION (168 min)

A. Direction to Students

1. Observe safety precautions
2. Follow order of procedure
3. Carry each position to completion

B. X-Ray exposure facilities

- a. One complete diagnostic assembly for each student
- b. Typical darkroom

C. General Plan for Conduct of Exercise

1. Request slip assignments
2. Step-by-step application of procedure
3. Immediate correction of errors
4. Final critique

D. Request Slip Assignments for This Exercise

1. Routine Esophagus
2. Routine Stomach and Duodenum
3. Routine Barium Enema

E. Students' Activities

NOTE: Make Assignment: Review after Class TM 8-280, pp 14-1 thru 14-13.

III. REVIEW (10 min)

A. Questions From Students

B. Review of Main Points

1. Students' appraisal

2. Instructor's appraisal

B. Closing Statement: A knowledge of these facts and their correct application will give consistently good quality radiographs of the esophagus, stomach, duodenum, and Barium Enema.

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE & SURGERY
X-RAY BRANCH.

*LP 38-520-098
036

Laboratory: Gall Bladder (3 hours)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Laboratory

REFERENCES:

TM 8-280, pp 14-14 to 14-17

STUDY ASSIGNMENT: Before class, review TM 8-280, pp 14-14 to 14-17

STUDENT UNIFORM AND EQUIPMENT: Not applicable

TOOLS, EQUIPMENT, AND MATERIALS: Typical clinical laboratory equipment

PERSONNEL: One instructor (MOS 91P2H or 91P4H) per each four students

INSTRUCTIONAL AIDS: Observation check sheets

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Practical exercise

I. INTRODUCTION (2 min)

A. Opening Statement: During the next 3 hours, you will practice the gall bladder procedures that are demonstrated in TM 8-280. When you arrive at your phase two assignment, you will probably find a technician that is extremely proficient at positioning for the gall bladder. This position is not a difficult position, although it is sometimes given to the best technician of the clinic. If you remember the information that you were given in class, and apply it to this position, you will find the gall bladder a very simple procedure.

B. Objectives

1. Given a request slip for the routine or additional views of the gallbladder, properly demonstrate in order of procedure a clinically acceptable radiographic position without aid of references.

2. Demonstrate proper operation of the radiographic equipment with particular attention to: Electrical protection, Radiation protection, and user/operator maintenance.

This Lesson Plan Supersedes LP 38-520-0980, 090.

3. In a clinical setting demonstrate proper medical ethics and patient handling procedures.

C. Class Procedure and Lesson Tie-in

This 3-hour block of instruction was preceded by a 1-hour demonstration (LP 38-520-067)

II. APPLICATION (130 min)

NOTE: Student specialist starts and completes practical exercise the same period.

A. Directions to Students

1. Observe safety precautions

2. Follow order of procedure

3. Carry each position to completion

B. X-ray exposure facilities

1. One complete diagnostic assembly for each student.

2. Typical darkroom

C. General Plan for Conduct of Exercise

1. Step-by-step application of procedure

2. Immediate correction of errors

3. Final critique

D. Procedure for Instructors

1. Maintain observation checklist

2. Critique errors as they occur

3. Verify observance of safety rules

4. Maintain order

1352

NOTE: Have students clean and secure all equipment

III. REVIEW (3 min)

A. Questions From Students

B. Review of Main Points

1. Students' appraisal

2. Instructors' appraisal

C. Closing Statement: A knowledge of these facts and their correct application will yield consistent diagnostic radiographs.

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE & SURGERY
X-RAY BRANCH

*LP 38-520-112
036

Laboratory: Repeat Positions (5 hours)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Laboratory

REFERENCES:

TM 8-280
All previous references for positioning.

STUDY ASSIGNMENT: TM 8-280 and all previous references for positioning

STUDENT UNIFORM AND EQUIPMENT: Not applicable

TOOLS, EQUIPMENT, AND MATERIALS: Typical clinical laboratory equipment

PERSONNEL: One instructor (MOS 91P2H or 91P4H) per each four students

INSTRUCTIONAL AIDS: Observation checksheets

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Practical exercise

I. INTRODUCTION (5 min)

A. Opening Statement: During the next 5 hours, you will practice the repeat positions that have been demonstrated in the classroom.

B. Objectives

1. Position a patient in a manner that will consistently yield diagnostic radiographs of any routine or special examination that you may not have as yet completed.

2. Work efficiently, effectively, and safely with a minimum of discomfort to the patient in producing radiographs of any routine that may be assigned you.

---

*This lesson plan supersedes LP 38-520-1120, 090.

1354

C. Class Procedure and Lesson Tie-in

None

II. APPLICATION (210 min)

A. Directions to Students

1. Observe safety precautions
2. Follow order of procedures
3. Carry each position to completion

B. X-ray exposure facilities

1. One complete diagnostic assembly per each pair of students.
2. Circuit breakers off
3. Typical darkroom

C. General Plan for Conduct of Exercise

1. Step-by-step application of procedure
2. Immediate correction of errors
3. Final critique

D. Procedure for Instructor

1. Maintain checksheet
2. Critique errors as they occur
3. Verify observance of safety rules
4. Maintain order

E. Positioning Assignments for This Period

Any position previously taught

NOTE: Have students clean and secure all equipment.

1353

III. REVIEW (10 min)

A. Questions From Students

B. Review of Main Points

1. Students' appraisal

2. Instructor's appraisal

C. Closing Statement: As an X-ray Specialist, you should now be able to perform any position routinely with adequate practice.

ACADEMY OF HEALTH SCIENCES, US ARMY
MEDICINE AND SURGERY DIVISION
X-RAY BRANCH

*LP 38-520-109
036

Laboratory: Makeup Positions (2 hours)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Laboratory

REFERENCES:

TM 8-280
Previous instruction

STUDY ASSIGNMENT: TM 8-280, pp 10 thru 12, and 14-1 thru 14-65.

STUDENT UNIFORM AND EQUIPMENT: Typical clinical laboratory equipment

TOOLS, EQUIPMENT, AND MATERIALS: Equipment found in typical clinical laboratory; X-ray request forms

PERSONNEL: One instructor (MOS 91P2H or 91P4H) per each four students

INSTRUCTIONAL AIDS: Observation checksheets

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Practical exercise

I. INTRODUCTION (2 min)

A. Opening Statement. During the next two hours, you will make up any positions that have been missed in the special positioning phase of the course.

B. Objectives

1. Position a patient in a manner that will consistently yield a diagnostic radiograph of any routine or any special examination that you have not as yet completed.

2. Work efficiently, effectively, and safely, with a minimum of discomfort to the patient in producing radiographs of any routine that may be assigned you.

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*This lesson plan supersedes LP 38-520-1090, 090.

1357

C. Class Procedure and Lesson Tie-in

All previous instruction

II. APPLICATION (78 min)

A. Directions to Students

1. Observe safety precautions

2. Follow order of procedure guide

3. Carry each position to completion

B. X-ray exposure facilities

1. One complete diagnostic assembly for each pair of students

2. Typical darkroom

C. General Plan for Conduct of Exercise

1. Request slip assignment

2. Step-by-step application of procedure

3. Immediate correction of errors

4. Critique each position

NOTE: Have students clean and secure all equipment.

III. REVIEW (10 min)

A. Questions From Students

B. Review of Main Points

1. Handling of patient

2. Critique overall performance

3. Radiation hazards

C. Closing Statement: The proper application of the procedures you have just practiced will result in acceptable radiographs.

ACADEMY OF HEALTH SCIENCES, US ARMY
MEDICINE AND SURGERY DIVISION
X-RAY BRANCH

*LP 38-520-110
.036

Laboratory: Spot Film Radiography (2 hours)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Laboratory

REFERENCES:

TM 8-280.

STUDY ASSIGNMENT: Before class review TM 8-280, pp 12-1 to 12-9

STUDENT UNIFORM AND EQUIPMENT: Not applicable

TOOLS, EQUIPMENT, AND MATERIALS: N/A

PERSONNEL: One instructor (MOS 91P2H or 91P4H) for each four students.

INSTRUCTIONAL AIDS: Observation checksheets; clipboard, radiographic request slips, radiographic illuminators, typical radiographic exposure room.

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Practical exercise

I. INTRODUCTION (5 min)

A. Opening Statement: As you already know, fluoroscopy is an examination in which we see the internal organs as they function. Fluoroscopy is a vital and necessary part of every clinic, but it has its drawbacks. After the lights go on and the machine is turned off, the only record you have of the examination is what you remember. Now we have the means of recording permanently the important and pertinent portions of the examination—the spot film device. You, as the X-Ray Specialist, are required to know how to operate and check the spot film device prior to these fluoroscopic examinations. The time saved, because of your knowledge and ability, can make the difference between life and death.

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*This lesson plan supersedes LP 38-520-110, 025

B. OBJECTIVES

1. Describe the steps in arranging an exposure room for fluoroscopic examinations.

2. Properly precheck the spot film device to insure it is operable prior to bringing the patient into the room.

C. Class Procedure and Lesson Tie-in

None

II. APPLICATION (80 min)

A. Preliminary Requirements

1. Assign machines

2. Designate working groups

3. Instruct student how to properly

   a. wear film badge

   b. energize unit

   c. improvise with main tube

   d. technique selection

   e. use foot switch

   f. use pressure cone

   g. fluoroscopic grid

   h. fluoroscopic timer

   i. radiographic timer

QUESTION: Where is the exposure button for the spot film device?

ANSWER: Foot switch

B. Operation of Spot Film Device

1. Insert film into tray
2. Place dry bone on table
3. Move fluoroscope unit over bone
4. Check alignment under fluoroscopy
5. Pull spot film tray forward
6. Make exposure

NOTE: Have student clean and secure all equipment.

III. REVIEW (5 min)

A. Questions From Students

B. Review of Main Points

1. Organizing exposure room
2. Operation of spot film device

C. Closing Statement: Your knowledge and skill as an operator of X-ray equipment ultimately dictates the care and treatment of the patient. They must be thorough and complete.

SFC WILLIAM HORNIG
*LP 38-520-111
036

ACADEMY OF HEALTH SCIENCES, US ARMY
MEDICINE AND SURGERY DIVISION
X-RAY BRANCH

Laboratory: Darkroom Operations (6 hours)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Laboratory

REFERENCES:

TM 8-280

STUDY ASSIGNMENT: Before class Review TM 8-280, pp 7-1 to 7-56

STUDENT UNIFORM AND EQUIPMENT: Not applicable

TOOLS, EQUIPMENT, AND MATERIALS: N/A

PERSONNEL: One instructor (MOS 91P2H or 91P4H) (Per each four students)

INSTRUCTIONAL AIDS: Typical radiographic darkroom

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Practical exercise (6 hours)

I. INTRODUCTION (2 min)

A. Opening Statement: For the next 6 hours you will be working in the darkroom. The first 3 hours will be spent working in the manual darkroom, one hour on the dry side one hour on the wet side, one hour changing solutions and cleaning the darkroom. The last three hours will be spent in the automatic darkroom, two hours processing films and the last hour cleaning the automatic processor.

B. Objectives

1. State the layout of a typical radiographic darkroom.

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*This lesson plan supersedes LP 38-520-111, 015.

2. Properly handle and process the flow of incoming exposed radiographs, using time, temperature development, and automatic processing methods.

3. Locate items of equipment in the darkroom with only safe light illumination.

4. Perform user/operator maintenance for both the manual and automatic darkroom.

5. Correctly mix chemicals for the manual and automatic processor.

C. Class Procedure and Lesson Tie-in

None

II. APPLICATION (253 min)

NOTE: There will be two students to a darkroom. During the manual processing portion of the practical exercise they will alternate under close supervision of one instructor, a period and a half each, on the dry side and then on the wet side. During the automatic processing practical exercise they will work two hours processing films and one hour cleaning the machine.

A. General Darkroom Layout

1. Entrances

   a. Maze

   b. Double door

   c. Single door

2. Passbox

3. Color of interior

4. Workbench

   a. Racks

   b. Film bin

  5. Dry side—wet side separation
  6. Tanks
  7. Dryers
- B. Dry Side Procedure
  1. Emptying passbox
  2. Unloading holders
  3. Hanging film
  4. Reloading holders
- C. Developing System
  1. Replenisher
  2. Other
- D. Wet Side Procedure
  1. Developer
  2. Rinse
  3. Hypo
  4. Wash
  5. Dryer
- E. Final Processing
- F. Solutions Change
  1. Drain tanks
     - a. Remove plug
     - b. Overflow danger

- 2. Clean tanks
    - a. Switch hypo and developer insert
    - b. Thoroughly scrub and rinse
- 3. Open containers
    - a. Care of hands
    - b. Stains on clothing
- 4. Mix solution
- 5. Refill master tanks

G. Automatic Processing

- 1. Emptying passbox
- 2. Unloading cassettes
- 3. Flashing ID on films
- 4. Processing films
- 5. Loading cassettes
- 6. Echelon maintenance
    - a. Removing crossover racks
    - b. Thoroughly scrub, rinse and dry
    - c. Ventilation of master tanks

H. Questions From Students

NOTE: Make assignment: Review after Class TM 8-280, pp 7-1 to 7-56.

III. REVIEW (15 min)

A. Questions From Students

B. Review of Main Points

- 1. Darkroom layout

2. Manual processing

3. Automatic processing

C. Closing Statement: Careful application of these fundamental rules while you are assigned to the darkroom will result in consistently high quality radiographs.

ANNEX E

SPECIAL RADIOGRAPHIC PROCEDURES AND TECHNIQUES

Peacetime: 37 hours
Mobilization: 37 hours

OBJECTIVE: Assist the medical officer in the preparation and management of patients during special examinations. Apply the principles of sterile technique when performing special presurgical radiographic surveys.

Subject and LP No	Lesson Objective	References
Contrast Media	Identify two classifications of contrast media. Identify four categories of contrast media. Identify five methods of introduction of contrast media. Identify four precautionary measures when working with contrast media.	TM 8-280, pp 11-1 thru 11-5, para 11-1 thru 11-19.
Fluoroscopy and Image Intensification	List the requirements of a fluoroscopic exposure room. State the difference between radiographic and fluoroscopic examinations. State the importance of the timers on the control panel during fluoroscopic examinations. Define image intensification. Identify the principles of image intensification. List the different uses of image intensification. Define cinefluorography. Discuss the basic fundamentals and functions of cinefluorography.	TM 8-280, pp 12-1 thru 12-4, para 12-1 thru 12-8, pp 12-4 thru 12-18, para 12-10 thru 12-23.
Examination of the Digestive System	Identify the anatomy involved with each examination of the esophagus, stomach, small bowel, and large bowel. Conclude patient preparation procedures for examination of the esophagus, stomach, small bowel, and large bowel. Arrange exposure room preparation procedure for examination of the esophagus, stomach, small bowel, and	TM 8-280, pp 14-1 thru 14-20, para 14-1 thru 14-10.

Subject and LP No	Lesson Objective	References
	large bowel. Determine the contrast media in proper ratios for examinations of the esophagus, stomach, small bowel, and large bowel. Given a radiograph, identify by name the anatomical structures demonstrated and the specific examinations of the esophagus, stomach, small bowel, and large bowel. Assist the radiologist during examinations of the alimentary tract (terminal objective). Distinguish the two primary factors which determine a decubitus position. Identify the anatomy involved with each examination of the gallbladder and biliary system. Conclude patient preparation procedures for examination of the gallbladder and biliary system. Arrange exposure room preparation for examination of the gallbladder and biliary system. Determine contrast media and method of introduction used for examinations of the gall bladder and biliary system. Given a radiograph, identify by name the anatomical structures demonstrated and the specific examination of the gallbladder and biliary system.	
Positioning: Stomach, Duodenum, Barium Enema, and Esophagus	Identify by name the position and anatomical structures demonstrated. Determine the correct routine. PFR/CRPR, film rundown, conefield, angle, and direction of the central ray, FFD, alignment breathing technique, immobilization film identification and captioning necessary to demonstrate the	TM 8-280, pp 8-44 thru 8-52, para 8-53 thru 8-64; pp 14-1 thru 14-20, para 14-1 thru 14-10.

Subject and LP No	Lesson Objective	References
	positions. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment, and the correct positioning data which would produce technical acceptable radiographs (accomplished in laboratory).	
Positioning: Gallbladder	Identify by name the position and anatomical structures demonstrated. Determine the correct routine, PFR/CRPR, film rundown, conefield angle and direction of the central ray, FFD alignment, breathing technique immobilization film identification and captioning necessary to demonstrate the positions. Given a request slip and a simulated patient in the X-ray laboratory, select the proper technical factors, accessory equipment, and the correct positioning data which would produce technical acceptable radiographs.	TM 8-280, p 8-51, para 8-63, p 14-14, para 14-7,
Automatic Processor	Identify the seven systems of systems engineering in automatic processing. Recognize the difference between automatic processing and manual processing. Determine the precautionary measures and proper maintenance required for the automatic processor.	TM 8-280, pp 7-41 thru 7-44, para 7-47 thru 7-56.
X-Ray Administration	Determine an ideal workflow pattern. Identify the advantage of a centrally located darkroom. Determine the handling of the SF 519a from its origin to the file. Identify the	AR 40-2, C 14; AR 340-18-9, C1 and C2.

Subject and LP No	Lesson Objective	References
	importance of the primary and secondary group numbers in the terminal digit filing system. Determine the disposition of exposed X-ray film according to AR 340-18-9, C1 and C2.	
Stereoscopy	Determine the purpose of stereoscopic examinations. Identify the equipment used in stereoscopic examinations. Determine the ratios and rules for tube angulation shift, directions, and correct identification placement. Identify the purpose of right-eye, left-eye films for correct stereo viewing. Compute the total tube shift for a given stereoscopic examination.	TM 8-280, pp 13-23 thru 13-28, para 13-27 thru 13-40.
Vasography	Classify the main divisions of vasography. Identify the purposes for vasography and lymphangiography. Identify the contrast media in vasography and lymphangiography. Determine the points of injection for each examination in vasography and lymphangiography.	TM 8-280, pp 14-36 thru 14-54, para 14-31 thru 14-41.
Body Section Radiography	Identify the purpose of body section radiography. State the effects the fulcrum height has on the depth of cut. Determine how amplitude and FFD affect the thickness of cut. After practice, properly assemble and disassemble the body section apparatus (terminal objective).	TM 8-280, pp 13-60 thru 13-64, para 13-69 thru 13-76.
Prenatal and Pelvimetry	Recognize the purpose of fetography and pelvimetry. Determine the preparation of a patient for a fetographic	TM 8-280, pp 13-1 thru 13-3, para 13-1

Subject and LP No	Lesson Objective	References
	and pelvimetric examinations. Identify the type pelvimetric procedure used most often in Army clinics. Recognize the difference between fetography and pelvimetry. After practice, properly position and produce clinically acceptable pelvimetric and fetographic radiographs (terminal objective).	thru 13-5.
Examination of the Urinary System	Determine the basic urographic examinations. Identify the contrast media used for basic urographic examinations. Properly schedule and instruct patients on the proper preparations for the basic urographic examinations. Identify radiographs of the basic urographic examinations. Recognize the emergency equipment and the need for it. After practice, competently assist the medical officer in performing urographic examinations (terminal objective).	TM 8-280, pp 14-20 thru 14-30, para 14-11 thru 14-21.
Foreign Body Localization	Evaluate foreign body localization. Distinguish the primary considerations with respect to presence. mature size, shape, entrance, and reference points. Identify the methods of foreign body localization in fluoroscopic and radiographic situations. Given a radiograph of Sweet's foreign body localization, identify same. Determine the technical factors. Identify equipment. Determine positioning. Given a radiograph of Comberg foreign body localization, identify same. Determine technical factors. Identify	TM 8-280, pp 13-35 thru 13-48, para 13-53 thru 13-56.

Subject and LP No	Lesson Objective	References
	equipment. Determine positioning.	
Medical Ethics	Recognize the principles of good medical ethics. Recognize the importance of cleanliness in good patient care. Determine who may act as a chaperone. After practice, display good medical ethics while handling patients (terminal objective).	TM 8-280, pp 9-1 thru 9-9, para 9-1 thru 9-35.
Soft Tissue	Determine the mA, kVp, and time range used in soft tissue radiography. Identify the accessory equipment used in soft tissue radiography. Properly position and handle patients with the least amount of embarrassment. Identify the type of film used in mammography examinations.	TM 8-280, pp 13-48 thru 13-50, para 13-57 thru 13-59.
Examination of the Nervous System	Identify the examinations of the nervous system. Recognize the contrast media used in each examination of the nervous system. Determine sites of injection for examinations of the nervous system. Identify purpose for each examination of the nervous system. After practice, provide competent assistance to the medical officer or radiologist in performing these examinations (terminal objective).	TM 8-280 pp 8-61 thru 8-66, para 8-81 thru 8-86, pp 14-54 thru 14-67, para 14-42 thru 14-47.
Skeletal Surveys and Scanograms	Identify the surveys associated with the skeletal system. Identify the purpose of each separate skeletal survey and of a scanography. Determine the procedures for the different skeletal surveys and for scanography.	TM 8-280, pp 13-16 thru 13-19, para 13-31 thru 13-32.

1370

Subject and LP No	Lesson Objective	References
Bronchography and Fluid Levels	Recognize the rules to be followed when doing fluid level examinations. Identify the methods of patient preparation for bronchograms. Recognize the two primary methods of introduction of the contrast medium and the contrast media used for bronchography. Given radiographs of a bronchogram, identify the structures demonstrated in bronchography.	TM 8-280, pp 13-13 thru 13-14, para 13-26 thru 13-28, pp 14-30 thru 14-36, para 14-22 thru 14-30.
Pediatric Radiography	Adjust the technical factors to achieve diagnostic films while working in pediatric radiography. Identify and utilize accessory devices to immobilize children for X-ray examinations. Distinguish the factors which cause pediatric radiography to be different and more difficult than the normal radiographic procedures.	TM 8-280, pp 13-19 thru 13-23, para 13-33 thru 13-36.

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DIVISION OF MEDICINE & SURGERY
X-RAY BRANCH

*LP 38-520-113
036

Contrast Media (1 hour)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES:

TM 8-280, pp 11-1 to 11-5

STUDY ASSIGNMENT: After class read TM 8-280, pp 11-1 to 11-5

STUDENT UNIFORM AND EQUIPMENT: TM 8-280

TOOLS, EQUIPMENT, AND MATERIALS: None

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Film packet of radiographs demonstrating routine and contrast medium filled organs, (See Annex A). Commonly used contrast media (See Annex B), chalkboard, chalk, radiographic illuminators, pointer, and eraser.

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Lecture

I. INTRODUCTION (3 min)

A. Opening Statement: During the past few weeks you have learned to demonstrate various bones and structures of the human body on a radiograph. Suppose we wished to demonstrate a particular organ, cavity, or certain vessel. With ordinary radiographic procedures, we could not do so. Therefore we must turn to some substance which would render a particular area radiopaque or radiolucent. These vital substances which tend to change the densities of a particular area when introduced into the body, are referred to as contrast media.

B. Objectives

1. List two classifications of contrast media.

2. List four categories of contrast media.

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*This lesson plan supersedes LP 38-520-113, 084

1374

3. State five methods of introduction of contrast media.

4. Identify four precautionary measures when working with contrast media.

C. Class Procedure and Lesson Tie-in

None

EXPLANATION (37 min)

NOTE: For the information below, the instructor will place a regular abdomen film and a regular lateral skull film on the viewbox for class observation. He will then place a barium enema and a cerebral angiogram on the viewbox for comparison.

A. Definition - substances that when localized in a specific system, organ or region, enable that area to be recorded on x-ray film or visualized on the flouorescent screen by influencing the absorption pattern of the emanating x-rays.

B. Organs and Systems Demonstrated

NOTE: The instructor will place a regular skull film, a regular chest film, and a regular abdomen film on the viewbox for class observation. He will then place a barium enema, a bronchogram, a ventriculogram, a pyelogram, and a double contrast barium enema for class observation and comparison.

1. Nervous system

2. Circulatory system

3. Digestive system

4. Urogenital system

5. Respiratory system

C. Primary Classification

1. Radiopaque - light area on film (resist passage of X-rays)

2. Radiolucent - dark area on film (permit passage of X-rays)

1373

D. Categories

NOTE: The instructor will display samples of various media. For pills it will be Telepaque, for powders it will be barium sulfate, for liquids it will be Hypaque, and Cholografin, and for iodized oils it will be Lipidol and Dionosil oily.

1. Alimentary tract radiopaques
    a. Barium sulfate
    b. Alternate alimentary tract radiopaques
    c. Cholecystopaques
2. Water soluble radiopaques
    a. Water soluble injectables
    b. Water soluble non-injectables
3. Viscous and/or oily radiopaques
4. Radiolucent media
    a. Gases
    b. Oxygen
    c. Carbon dioxide
    d. Room air

QUESTION: What is the purpose of using contrast media?

ANSWER: To demonstrate specific organs or systems on films by changing the densities in the area to be observed.

E. Methods of Introduction

1. Oral
2. Intravenous
3. Rectal
4. Intramuscular
5. Direct

1376

LP 38-520-113
036

QUESTION: Are iodized oils injected intravenously?

ANSWER: Never, physical and chemical properties could cause great damage to the patient, possibly death.

QUESTION: When a powder is used as a contrast medium, what is it mixed with?

ANSWER: Water

F. Precautions

NOTE: The instructor will show a spoiled medium and a good medium for class observation and comparison. (Discolored, crystallized and solid particles)

1. Identification of media

2. Spoiled media

3. Methods for testing allergies

    a. Medical records check

    b. Oral

    c. Ophthalmic (one drop in the eye)

    d. Subcutaneous (under skin)

    e. Intravenous

4. Post/injection precautions - reactions

    a. Itching

    b. Flushed appearance

    c. Watery eyes

    d. Faintness

    e. Hives

    f. Nausea

    g. Breathing difficulties

    h. Cyanosis

    i. Unconsciousness

QUESTION: What are some of the ways of recognizing a spoiled medium?

ANSWER: By the color, crystallization, and solid particles in the medium.

G. Selections, Strength, and Introduction

1. By radiologist
2. By patient's physician

QUESTION: What are the five methods for testing for allergies?

ANSWER: Medical records check, oral, ophthalmic, subcutaneous, and intravenous.

QUESTION: How will radiopaques and radiolucents appear on films?

ANSWER: Radiopaques will appear white, and radiolucents will appear dark.

QUESTION: What are the two primary classifications of contrast media?

ANSWER: Radiopaque and Radiolucent

H. Questions From Students

NOTE: After class assignment - study TM 8-280, pp 11-1 to 11-5.

III. SUMMARY (5 min)

A. Review of Main Points

1. Primary classifications
2. Categories
3. Methods of introduction
4. Precautions

B. Closing Statement: Contrast media are generally used during special procedures. You as an X-ray Specialist should master the ability to recognize each contrast medium for each special examination. Then you will be able to render assistance to a Radiologist or Physician. Above all, you will have paved a way for your own personal success in life.

ACADEMY OF HEALTH SCIENCES, US ARMY *IM 38-520-113
DIVISION OF MEDICINE & SURGERY 036
X-RAY BRANCH

Contrast Media

During the past few weeks you have learned to demonstrate various bones and structures of the human body on a radiograph. Suppose we wished to demonstrate a particular organ, cavity, or certain vessel. With ordinary radiographic procedures, we could not do so. Therefore, we must turn to some substance which would render a particular area radiopaque or radiolucent. These vital substances which tend to change the densities of a particular area, when introduced to the body, are referred to as contrast media.

Contrast media are any agents or substances that when localized in a specific system, organ or region, enable that area to be recorded on x-ray film or visualized on the fluorescent screen by influencing the absorption pattern of the emanating x-rays.

In order to differentiate details in a radiograph, an object must show densities lighter or darker than its surroundings. To accomplish this, there must be a difference in the absorption of the x-rays that pass through the object compared to the x-rays that pass alongside it. The absorption rate of any substance or tissue depends on its density and composition. In many instances; the differential absorption is too insignificant to produce adequate contrast for radiographic or fluoroscopic visualization. In a radiographic sense, this situation is rather evident in the case of the homogeneous tissue masses comprising the digestive system, respiratory system, urinary system, and the nervous system. Basically the problem is to introduce a contrast medium into the system so that x-rays will be either absorbed or pass through it to a greater or lesser degree relative to adjacent tissue structure.

Radiopaque substances are the first of two primary classifications. These are the contrast media that will absorb or hinder the passage of x-rays. This characteristic will cause the resulting x-ray image to appear white (devoid of silver) and cast shadows on the fluorescent screen. Liquids, pills, and powders in suspension are representative of this class of contrast media.

The second classification of contrast media are the radiolucent media. These media permit x-rays to pass through them producing black images on the radiographs or increased brightness on the fluoroscopic screen. Air, oxygen, carbon dioxide, and helium are representative of this classification of contrast media.

Contrast media appear in many forms. Air and gases form all of the radiolucent classifications. Radiopaque media are found in all of the following forms--liquids, pills, or powders.

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*This instructor's manuscript supersedes IM 38-520-113, 084

1379

There are two types of liquid media—sterile aqueous solution and iodized oil. Sterile aqueous solution are those in which water is used as the base for the solution. These are used primarily for intravenous injections. Iodized oils are those solutions which use an oil for the base of the solution. Because of their physical and chemical properties iodized oils are never injected intravenously.

Another category is pills. These are media with all the necessary products concentrated into pill form and are usually taken orally by the patient.

The last category is powder. These are never administered in powder form, but are mixed with water to form suspensions. These are taken orally by the patient, or given rectally with the enema given to the patient by the Specialist

Introduction of a contrast medium into a system depends to a large extent upon the nature of an organ or system, tolerances of the patient, and functional or mechanical impediments. Oral, intravenous, direct, rectal, and intramuscular are the methods most commonly employed in hospitals.

When the oral method is used, the patient will swallow the contrast medium necessary for the examination to be accomplished. Pills, powders, and various liquid solutions are administered this way.

When the intravenous method is employed, the sterile aqueous contrast medium is injected into a vein or artery. These solutions are usually organic iodine compounds containing various percentages of iodine.

The direct method is used when the radiologist wants to inject the medium directly into the area under consideration. This is done with instruments such as needles, catheters, and cannulas. The term "retrograde" is frequently used in connection with this method, for example, retrograde pyelography. In this examination the medium is injected via catheters into the pelvis. Sterile aqueous solutions and iodized oils are frequently employed in this method.

The rectal method is used when the radiologist wants to visualize any or all of the large bowel; liquid solutions and air are the most commonly used for this method. Introduction is usually accomplished by the Specialist in doing barium enemas. The Specialist makes a barium suspension for the barium enema and for the double contrast barium enema, the Specialist will introduce both barium and air into the large bowel.

The intramuscular method is used primarily for elimination urography in infants. The infant or small child make intravenous injection inordinately difficult or impractical, therefore the radiologist will usually inject the medium into the muscle.

1378

When handling contrast media, the Specialist must be positive that he has the proper one. Identification on the bottle should be checked at least three times. When the Specialist first grasps the bottle he should check the identification as he places it on the tray, and as it is removed from the tray it should be checked again. Any bottle with a label that is missing, faded or hard to define should be discarded.

Some iodized oils will spoil if left exposed to light. Spoiled media should be labeled as such and set aside for comparison with the iodized oils to be used. This is a useful check point for the Specialist.

Contrast media can be highly toxic to some people. These people have allergies and if it is not discovered, will have serious effects when the medium is administered. There are five common methods to check for patient allergies.

The first method is the easiest--it is merely a check on the patient's medical records. Any known allergies the patient has will be listed in the records.

The next four methods are merely short tests to be performed prior to the medium being administered.

The first of these tests is the oral test. To accomplish this test, one or two drops of the medium to be used is placed under the patient's tongue. The Radiologist or the Specialist will wait a few minutes, then check the area for any symptoms that would indicate an allergy.

The second test is a subcutaneous test. A small amount of the medium to be used is injected just under the skin. Again watch for symptoms that would indicate an allergy to the medium.

The third test is an ophthalmic test. One or two drops of the medium to be used is placed into the patient's eye to accomplish the test. Then, after a short period of waiting the eye is checked for symptoms that would indicate an allergy to the medium.

The fourth and last of these tests is the intravenous test. A small amount of the medium is placed into the patient's vein. The Specialist must keep a close watch on the patient and ask the patient for any symptoms that might occur.

After completion of an examination, a close watch must be kept on the patient for any post injection symptoms. These could be any one of a number of things such as fainting, dizziness, nausea, etc.

1381

IM 38-520-113
036

The selection, strength and introduction of most media are not the Specialist's responsibility, but that of the Radiologist or the patient's physician. The Specialist does not attempt to select the contrast medium, but must await instructions from the Radiologist.

Contrast media are generally used during special procedures. You as an x-ray Specialist should master the ability to recognize each contrast media for each special examination. Then you will be able to render assistance to any Radiologist or Physician. Above all you will have paved a way for your own personal success in life.

1380

SSG Obie G. Bedford

ACADEMY OF HEALTH SCIENCES, US ARMY
MEDICINE AND SURGERY DIVISION
X-RAY BRANCH

*LP 38-520-114
027

Fluoroscopy and Image Intensification (4 hours)

COURSES PRESENTED TO: 313-91P10, X-Ray Specialist Course

PLACE: Classroom (1st and 2d hours); Laboratory (3d and 4th hours)

REFERENCES: TM 8-280.

STUDY ASSIGNMENT: After class, read TM 8-280, pp 12-1-12-4 and 12-9-12-18

STUDENT UNIFORM AND EQUIPMENT: TM 8-280

TOOLS, EQUIPMENT, AND MATERIALS: None

PERSONNEL: One instructor (1st and 2d hours); one instructor for every four students (3d and 4th hours)

INSTRUCTIONAL AIDS: Typical exposure room capable of performing fluoroscopy and/or image intensification

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Lecture (1st and 2d hours); Demonstration (3d and 4th hours)

FIRST AND SECOND HOURS

I. INTRODUCTION (5 min)

A. Opening Statement: Practically all X-ray clinics in the Army perform fluoroscopic procedures. These procedures are accomplished usually at the beginning of the day and continue approximately three to four hours. Although fluoroscopy was one of the greatest advancements in the X-ray field, it has many shortcomings. These shortcomings were realized, and through the efforts of several companies who deal in X-ray equipment, the image intensification and cinefluorographic unit was developed. The image intensification unit not only made up for the shortcomings of fluoroscopy but also added several new aspects to the X-ray field. This period of instruction we shall discuss the pertinent aspects of fluoroscopic and intensification procedures.

B. Objectives

1. List the requirements of a fluoroscopic exposure room.
2. State the difference between radiographic and fluoroscopic screens.

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*This lesson plan supersedes LP 38-520-114, 125, and LP 38-520-132, 125.

3. List the two primary accessory devices used in fluoroscopic examinations.
4. State the importance of the timers on the control panel during fluoroscopic examinations.
5. Define image intensification.
6. Identify the principles of image intensification.
7. List the different uses of image intensification.
8. Define cinefluorography.
9. Discuss the basic fundamentals and functions of cinefluorography.

C. Class Procedure and Lesson Tie-in

None.

II. EXPLANATION (75 min)

A. Fluoroscopy

1. Definition
2. Purpose
3. Fluoroscopic Room
    a. Lightproof
        (1) Windows
        (2) Doors
    b. Lighting
    c. Proximity to latrine

QUESTION: How much time is required for dark adaptation?

ANSWER: 15 to 30 minutes.

4. Equipment
    a. Combination fluoroscopic and radiographic unit
        (1) Fluoroscopic table

    - (a) Bucky tray
    - (b) Overhead tube
    - (c) Tilt Table
    - (d) Shoulder rest
    - (e) Foot rest
    - (f) Fluoroscopic screen

QUESTION: When are the foot rest and shoulder rest used?

ANSWER: The foot rest is used when the table is to be placed in the upright position and the shoulder rest is used when the patient is to be positioned where the head and shoulders will be lower than the feet.

- (2) Spot film device and films

NOTE: Show and explain spot films.

  - (a) Location
  - (b) Cassette placement and number of exposures
  - (c) Change from fluoroscopy to radiography
  - (d) MA used
- (3) Fluoroscopic tube - auxiliary
  - (a) Location
  - (b) Lead shutter placement
  - (c) U-arm attachment
- (4) Fluoroscopic panel
  - (a) Technique selector
  - (b) Bucky switch
  - (c) Exposure selector switch
  - (d) Fluoroscopic timer
  - (e) Factors
    - 1 kVp 90 to 120

2 mA 3-5

3 Time

QUESTION: What KVP and MA ranges are used in fluoroscopy?

ANSWER: 90 to 120 KVP and 3 to 5 MA.

b. Accessory table and cabinet

5. Precaution
   a. Dark adaptation
   b. Filtration
   c. Tube skin distance
   d. Time used
   e. Size of exposed field
   f. Lead gloves, aprons, and protective shields

B. Image Intensification

1. Principles of image intensification
   a. Definition: an electronic method of raising the relative brightness levels of the fluoroscopic image.
   b. Purpose of image intensification
      (1) Improve visual acuity
      (2) Eliminate dark adaptation
      (3) Decrease radiation exposure to the patient during fluoroscopic examinations
      (4) Broadens the scope of fluoroscopic procedures

2. The image intensification tube
   a. Components
      (1) Glass envelope (vacuum tube)
      (2) Input phosphor
         (a) Fluorescent layer (input screen)

(b) Photoelectric layer (photocathode)

(3) Electrostatic focusing

(4) Anode aperture

(5) Output screen

(6) Lens system

(7) Field sizes

b. Functional aspects

(1) X-rays pass through target and strike input screen which produces a fluorescent image

(2) Fluorescent image is picked up by the photocathode and is converted into an equivalent electronic image

(3) Electronic image is projected across the tube and the electrons are accelerated by 25 to 30 KV

(4) Minification and intensification of electronic image through a "coning down" process

(5) Electronic image strikes output screen and is converted back to a fluoroscopic image

(6) Collected emissive light is then viewed by the use of a magnifying device and optic mirrors

QUESTION: How does the image intensification increase the brightness level of the fluroscopic image?

ANSWER: Through acceleration of electrons intensifying and minifying the image.

c. Relationship of image intensifying tube to:

(1) X-ray source

(2) Patient

(3) Viewer

3. Fundamental operacional considerations

a. Supports and counterbalances

b. Traveling crane and range of maneuverability

c. Attachments and locking devices

d. Fluoroscopic spot-film assembly as used with the image intensifier

e. Electrical connections and adjustments

4. Accessory devices

    a. TV camera and set

    b. Cinecamera

    c. 70mm spot-film device

    d. Videotape recorder

5. Advantages of image intensification

    a. Increased brightness level improves visual acuity

    b. Eliminates need for dark adaptation

    c. Eliminates need for a totally darkened room

    d. Can be viewed by use of a TV camera and set

    e. Can be recorded by either a cinecamera or videotape recorder

QUESTION: How do image intensifiers increase the efficiency of the X-ray clinic?

ANSWER: By saving time normally consumed waiting for dark adaptation, increasing visual acuity and adding new dimensions to the X-ray field.

6. Disadvantages of image intensification

    a. Inability to increase contrast

    b. Cost

C. Cinefluorography

1. Definition: cinefluorography is a method for producing motion pictures of the fluoroscopic image.

2. Basic components

    a. Source of X-ray

   b. An absorber (patient)

   c. Intensification system

   d. Intensified image

   e. Optical system

   f. Recording system (motion picture camera)

   g. Synchronizing system

3. Motion picture camera

   a. Light-tight container

   b. Lens optical system

   c. Shutters

   d. Synchronization system

   e. Film sizes

4. Uses

   a. Angiocardiography

   b. Voiding cystograms

   c. Arteriograms

   d. Functional studies of bony structures

      (1) Flexion and extension views of the spine

      (2) Stress views of joints

QUESTION: During what examination is cinefluorography used at its utmost capacity?

ANSWER: Angiocardiography.

5. Advantages

   a. Permanent record of functional studies

   b. Prevention of excessive irradiation

   c. Useful as teaching aid for the radiology resident

C. Questions from Students

1389

LP 38-520-114
027

NOTE: Make study assignment. Review TM 8-280, pp 12-1 through 12-4 and pp 12-9 through 12-18.

III. SUMMARY (10 min)

A. Review of Main Points

1. Fluoroscopic Room

2. Fluoroscopic Equipment

3. Precautions

4. Principles of Image Intensification

5. Image Intensification Unit

6. Uses of Cinefluorography

7. Components of Cinefluorography

B. Closing Statement: You can now realize the great contribution fluoroscopy and image intensification has made in opening new potential in X-ray and saving enormous amounts of time. It has greatly increased the efficiency of the X-ray clinic, conserved numerous man-hours, and reduced the radiation exposure to the patient. With a thorough knowledge of fluoroscopy, image intensification and cinefluorography, the X-Ray Specialist will be able to aid in performing these examinations with the least amount of discomfort to the patient and the maximum effectiveness for the Radiologist.

THIRD AND FOURTH HOURS

I. INTRODUCTION (10 min)

A. Opening Statement: The first two hours were spent discussing the principles of image intensification and fluoroscopy. The next two hours will be spent applying these principles to practical application.

B. Objectives

1. Properly set up the machines for fluoroscopy and image intensification.

2. Properly operate the spot film device on the fluoroscopic and image intensification units.

C. Class Procedure and Lesson Tie-in:

None.

1388

II. APPLICATION (75 min)

A. Preliminary Requirements

1. Assign machines
2. Designate working groups
3. Instruct student how to properly
    a. Wear film badge
    b. Energize unit
    c. Set controls for fluoroscopy and/or image intensification
    d. Technique selection
    e. Use foot switch
    f. Use pressure cone (fluoroscopic)
    g. Fluoroscopic grid
    h. Fluoroscopic timer
    i. Radiographic timer

QUESTION: Where is the exposure button for the spot film device?

ANSWER: Foot switch.

B. Operation of Spot Film Device

1. Insert film into spot film device
2. Place mannequin on table
3. Move fluoroscopic of image intensifying unit over mannequin
4. Check alignment under fluoroscopic screen and/or monitors
6. Remove and process spot films

NOTE: Have student clean and secure all equipment.

III. REVIEW (5 min)

A. Questions from Students

B. Review of Main Points

1. Setting up a typical fluoroscopic room

2. Operation of spot film device

C. Closing Statement: Your knowledge and skill as an operator of X-ray equipment ultimately dictates the care and treatment of the patient. They must be thorough and complete.

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*IM 38-520-114
027

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X-RAY BRANCH

Fluoroscopy and Image Intensification

Practically all X-Ray Clinics in the Army perform fluoroscopic procedures. These procedures are accomplished usually at the beginning of the day and continue approximately 3 to 4 hours. This means you will be working directly under the supervision of the medical officer. Fluoroscopic procedures are accomplished with dark adaptation. This period we will discuss the pertinent aspects of fluoroscopic procedures.

The fluoroscope is a very valuable tool as an aid in the diagnosis and treatment of many types of disease and injury. Most hospital clinics devote several hours per day to fluoroscopic examinations. Since you, the X-Ray Specialist, will be directly assisting the Radiologist as he performs these fluoroscopic examinations, it will be important for you to have a working knowledge of fluoroscopy in order to perform your duties with a maximum of efficiency and a minimum of discomfort to the patient.

Fluoroscopy is one of the two general methods of radiographic examination by which an image is produced on the fluorescent screen when the part to be examined is placed between the energized tube and the fluoroscopic screen. One great difference between fluoroscopy and conventional radiography is that the fluoroscopic image persists only during X-ray excitation of the screen and is, therefore, temporary and permits only a limited time for examinations, whereas the radiographic image is a permanent record and can be studied at leisure. Another difference is that in the fluoroscopic image, the dense portions of the part under examination appear as dark areas on the screen and the radiolucent portions as light areas, whereas the reverse is true of the radiographic image.

Fluoroscopy permits observation of gross physiology--that physiology concerned with motion of the heart, diaphragm, and alimentary tract, transport of contrast media through the alimentary tract, etc., as well as gross anatomy. The great value of fluoroscopy lies in the opportunity for correlation of anatomy and physiology, normal or abnormal. Added value accrues through the ready alteration of the patient's position under fluoroscopic observation; this serves to localize an abnormality in relationship to other structures and to establish which positions will be advantageous in radiography. Furthermore, such procedures as progressive filling of sinus tracts or the bronchial tree by contrast media may be guided fluoroscopically to insure that films be exposed at the proper time (that is, with condition of neither incomplete outlining nor overfilling).

The radiographic room used for fluoroscopy must be capable of being made completely light-tight since any extraneous light will interfere with the visualization of the image on the fluoroscopic screen. The windows must be painted black or covered with lightproof curtains, and the doors must be sealed with felt or similar material to prevent light leaks. Ventilation is important

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*This instructor's manuscript supersedes IM 38-520-114, 125.

1393

in a closed room for the comfort of the patient as well as the Radiologist and X-Ray Specialists; so, if air-conditioning is not used, some means must be used to circulate the air within the room and to exhaust stale air.

All lights must be controlled from within the room to prevent the white lights from being turned on accidentally by someone outside the fluoroscopy room. Before the white lights can be turned on or the door opened, the radiologist must be warned so that he can replace his dark adapter goggles. During the examination, the room will be much darker than your darkroom since the only illumination is a dim red bulb in the room and one in the control panel. These bulbs are tied in circuit with the foot switch in such a way that when an exposure is made, they will go out leaving only the light from the screen during the exposure.

The fluoroscopic room must be close to a latrine to prevent undue delay and discomfort to the patient undergoing a barium enema. It would be best if the latrine opened into the fluoroscopic room since it is possible that the latrine outside the fluoroscopy room could be in use when needed.

It is desirable to have a combination radiographic-fluoroscopic unit with a tilt table, automatic changeover switch for instantaneous spot film work, and an over-table tube so that follow-up radiographs can be made without having to move the patient to another room.

To prepare the table for fluoroscopy, the Bucky must be positioned at the foot of the table, the over-table tube must be moved out of the way, and the table set in the upright or horizontal position as needed. For chest and upper gastrointestinal work, the table will be upright; but for barium enemas and myelography, the table will be horizontal.

When the table is to be tilted with a patient in position, a footrest or shoulder rest must be used to prevent the patient from sliding or falling off the table.

The fluoroscopic screen is freely movable in all directions to permit easy handling and operation. The yellow-green fluorescent screen is composed of zinc sulfide crystals which fluoresce in the yellow-green band of the spectrum for the most efficient viewing. This screen differs from the intensifying screens in cassettes in that the white screens in cassettes are calcium tungstate and fluoresce in the blue-violet band of the spectrum for the most efficient action on the emulsion of X-ray film.

The fluoroscopic screen will be covered with a sheet of leaded glass to protect the viewing physician from primary radiation. Both types of screen light up when struck by X-rays; but since the light from the screens in the cassette act on film, the dense areas where the radiation is absorbed will be light in the image and the thinner areas will be dark; whereas in fluoroscopy, we look directly at the image on the screen. This image will be the opposite of the image on film; the dense areas will be dark and the thinner areas will be light.

Attached to the fluoroscopic screen will be a device to provide automatic changeover from fluoroscopic factors to radiographic factors so that instantaneous exposures of small areas can be made during fluoroscopy. To make a spot film, the Radiologist moves the film carriage from the fluoroscopic to the radiographic position. A micro switch changes the fluoroscopic MA to radiographic MA of 100 or 150 MA, depending on the make of the machine. Usually from one to four exposures are made on a film according to the wishes of the Radiologist. Accessories such as grids, pressure cones, and masks are available for use.

The fluoroscopic tube is sometimes called the auxiliary tube and is set on runners located under the table. These runners are set to give a constant target skin distance of 12 - 18 inches. Field control is provided by adjustable lead shutters moving in opposite directions located directly in front of the exit portal of the tube. These shutters should be permanently set to provide a minimum of 1/4 inch, unlighted screen when the screen is at its maximum height and the shutter at widest opening during an exposure. A "U" shaped arm keeps the tube centered to the screen at all times.

The exact factors to be used in fluoroscopy will depend on the wishes of the individual doing the exam and the structure to be examined; however, between 90-120 KVP, 3 to 5 MA and a timer setting of 5 minutes is used for most fluoroscopic work.

To set the control panel, the technic selector must be set to the fluoroscopic setting, the Bucky switch to the out position, radiographic timer to spot film time, fluoroscopic timer energized and set to the prescribed time, foot switch energized, and factors set as prescribed. The fluoroscopic timer when set is the only means of controlling the MAS during fluoroscopy.

The accessory table must be placed close enough to be convenient, yet out of the way enough to allow easy movement through the room when the lights are out. All items that will be needed for the day's examinations such as sterile trays, contrast media, glasses, and other items will be placed here; but the film for the spot film device must be protected from stray radiation and will be kept in the booth or a lead lined box in the exposure room. Care must be taken to keep the exposed and unexposed film separated to prevent double exposures.

For the protection of the patient, Radiologist, and Specialists, there are a few very important rules to follow in fluoroscopy. Adequate dark adaptation is extremely important. The level of light from a sheet of white paper in ordinary reading light is approximately 30,000 times brighter than the fluoroscopic screen during the examination of a thick abdomen. Between 15 and 30 minutes are needed to properly adapt. This can be done in two ways; the Radiologist can sit in a completely darkened room for the necessary time, or he can wear dark adapter goggles. Although 15 to 30 minutes are needed to adapt adequately, only a flash exposure to white light will cause the loss of this dark adaption.

The fixed filtration in the tube head must be at least 2 1/2 mm aluminum, and it is recommended that no less than a 15-inch target skin distance be used

1395

for the protection of the patient. Both the time of exposure and the field of exposure should be kept at a minimum.

Distance is the best safety factor against radiation; but since we cannot get distance, we must use shielding. Wear your lead gloves and aprons at all times; and when you are not needed to help at the table, you should remain in the protective booth.

To improve the fluoroscopic image, the same principles are involved that are used to improve the radiographic image. A small aperture corresponds to a small conefield, a small focal spot for detail, minimum part screen distance, a grid to absorb secondary and a lightproof room since the radiologist must see the image.

Now that you understand the basic principles of fluoroscopy, I am sure that you realize it has many shortcomings. These shortcomings were realized; and through the efforts of several companies who deal in X-ray equipment, the image intensification unit was developed. The image intensification unit not only made up for the shortcomings of fluoroscopy, but also added several new aspects to the X-ray field.

What is image intensification? Very simply, it is an electronic method of raising the relative brightness level of a fluoroscopic image. You will remember from your class on fluoroscopy that the fluoroscopic image is approximately one-thirty-thousandth as bright as this piece of paper. That is not very bright. Just this low brightness level in fluoroscopy gives it many bad aspects. These disadvantages in fluoroscopy were eliminated in image intensification. For instance, because of the brighter image with an intensifier, there is no longer a need for dark adaptation. Imagine all the time you can save by eliminating the normal 15 to 30 minutes you would have to take for dark adaptation in fluoroscopy. You could come to work at 0700 hours and start your fluoroscopic examination from the time you walked in off the street. Obviously, if there is no need for dark adaptation, there is no need for a totally darkened exposure room. This is extremely helpful to you and psychologically important to the patient. In a room that has a little light, rather than no light at all, there is less chance of accidents occurring since you can see what you are doing. For the patient who may have never been in an exposure room before, it is less frightening if he or she can see what is going on.

Another important aspect of image intensification is the decreased radiation exposure to the patient. This is obvious in the starting technic that you will use. It is 1/2 to 2 MA, 70 to 120 KV. You can see that in image intensification, as in all other aspects of the X-ray field, radiation protection is of primary importance.

We will discuss later how intensifying units have broadened the scope of the X-ray field. But image intensification has opened new facets that were once just a dream.

1396

Before we can work with this unit, we must first know basically how it works. Let us look at the main components of the image intensifiers and see how they work and what they do. First, as in the normal X-ray tube, we have a glass envelope which is a vacuum tube and an input phosphor. The input phosphor is divided into two parts consisting of the input screen and the photocathode. Along the inside of the tube, there are devices that electrostatically focus the image. Finally, there is the anode aperture, output screen and the lens system. These are the main components of the image intensification tube.

Let us see how these parts work. First, we need a source of X-rays so we have the conventional X-ray tube located under the table as in normal fluoroscopy. The X-rays pass through the target and strike the input screen which produces a fluorescent image much like the one in fluoroscopy. This fluorescent image is transferred to the photocathode and is converted into an equivalent electronic image. The electronic image is then projected across the tube.

As these electrons travel across the tube, they are "coned down" and focused by the electronic focusing devices. During this phase, the electrons are also accelerated 25 to 30 KV. Because of this acceleration, we have an intensification of the image. The coning-down process, or minification, of the image also intensifies the image. So that you can better understand the effect of coning down to intensify the image, try to imagine the existing light in this room concentrated into an area about one-eighth its size. Have you ever tried to start a fire with a magnifying glass? You take the existing light from the sun and cone it down to make a brighter and better base. The minification process in the image intensification tube works in much the same way. This minified and intensified image then strikes the output screen and is converted back to a fluoroscopic image. The collected emissive light is then viewed by use of a magnifying device and optic mirrors.

You are probably asking yourself, "Then how is all this set up for use in the clinic?" The X-ray tube is located under the table. The patient is on the table as in fluoroscopy and you still use the fluoroscopic carriage. The difference is the lead glass and the zinc sulfide screen are removed. The film carriage for spot films remains intact.

The image intensification unit itself has many exterior components that you will need to know about. First, there are a complex set of weights and counter balances that make the unit easy to handle. These weights, combined with the overhead traveling crane, give the unit a high degree of maneuverability. On the unit and the fluoroscopic carriage, there are attachments and locking devices that simply hold the unit onto the fluoroscopic carriage during examinations. There are also many electrical connections and adjustments that you will be concerned with in the clinic.

As we said earlier, there are many accessory devices used with the intensifier. There is a television camera unit that is very often used in the clinic. Using a separate set of optic mirrors, a television camera picks up the image and projects it onto a television screen. Also, a cinecamera unit can be installed on the intensifying unit. We will discuss cinefluorography

1397

a little later in the class; but for now, it is simply a method for taking motion pictures of a fluoroscopic image. A 70 mm spot-film device can also be used with the intensifying unit to take spot films on 70 mm film as you saw in the class on photoroentgenography. In some clinics, you may also see a videotape recorder that is hooked up to the intensifying unit.

Now that we know how the unit works, its component parts, and accessories, let us look at some of the advantages. As you have seen, the increased brightness level also eliminates the need for dark adaptation as we know it now. There is no longer a need for a totally darkened room. This helps you to see what you are doing during a fluoroscopic examination and psychologically affects the patient in that he can see what is going on. The image can be viewed either by optic mirrors or television set which is a method of radiation protection for you and the radiologist. Another advantage is the ability we now have of recording the examinations with a videotape recorder, or a cinecamera. As with any type of equipment, there are disadvantages as well as advantages, image intensifiers are no exception. One of the disadvantages is the inability to increase contrast. The other is the inability to reduce the radiation dose to the patient. The reason this is listed as a disadvantage is, although we use much less radiation than in regular fluoroscopy, we cannot further reduce this due to the machine's capability limitation. While working in X-ray, you as the technician should always keep in mind the different means of radiation protection for the patient. Every day, there is someone, somewhere, looking for the means to reduce the amount of radiation a patient receives. At this point, there is nothing that produces so little radiation to the patient and accomplishes as satisfactory a fluoroscopic procedure as an image intensification unit, but it is still not perfect. In talking about image intensification, we mentioned that one of its advantages and capabilities was that it can be used in conjunction with either a television camera or a motion picture camera. The name used when making motion pictures of a fluoroscopic procedure is "cinefluorography." Cinefluorography is, by definition, a method for producing motion pictures of a fluoroscopic image.

If you were to place a camera in front of the patient and the X-ray tube, the X-rays would expose the film. So we bleed some of the light from the intensified image and deflect it by use of the optical system into the recording system or camera. Within the camera, there are some special devices you should know about, one being the special shutters that are used. This shutter opens and closes as each frame of the film passes in front of it. The synchronizing device makes an exposure as the shutter opens and closes as each frame of the film passes in front of it. The synchronizing device makes an exposure as the shutter opens and shuts the tube off when the shutters are closed. In actuality, you are making a series of very short exposures when doing cinefluorography. The synchronizing device saves wear and tear on the tube and reduces radiation received by the patient.

One of the many uses of cinefluorography is during angiocardiography. Angiocardiography is a difficult procedure and is performed rapidly. If the procedure was done under fluoroscopy, a radiologist might miss an abnormality. But with cinefluorography, he could view the film as often as he wished, at any time he wished. Other examinations that are done using cinefluorography are arteriograms, voiding cystograms, and functional studies of bony structures. For example, a flexion and extension view of the spine or stress views of the joints.

There are several distinct advantages to cinefluorography. One of them is that you have a permanent record of a complete fluoroscopic examination instead of just portions of it as you have with spot films. A radiologist can review an examination that was done six months ago on a patient and see exactly what occurred. Another advantage is that there is, to some degree, a reduction of radiation to the patient. If a radiologist was doing an examination and saw the tail end of an abnormality occur as the contrast media flowed through, he might have to stop the exam, wait for the area to clear itself of contrast media, reintroduce more contrast media and start the examination again. With the use of cinefluorography, he could simply continue with the examination and view the entire procedure later. Finally, the films are extremely useful as a teaching aid for radiology residents.

You can now realize the great contribution fluoroscopy and image intensification has made in opening new potential in X-ray and saving enormous amounts of time. It has greatly increased the efficiency of the X-ray clinic, conserved numerous man-hours, and reduced the radiation exposure to the patient. With a thorough knowledge of fluoroscopy, image intensification and cinefluorography, the X-Ray Specialist will be able to aid in performing these examinations with the least amount of discomfort to the patient and the maximum effectiveness for the Radiologist.

1399

SFC WILLIAM HORNIG
LP 38-520-115
105

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE & SURGERY
X-RAY BRANCH

Examination of the Digestive System (5 hours)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES: TM 8-280

STUDY ASSIGNMENT: (1) Before clas scan TM 8-280, pp 14-1 to 14-17

STUDENT UNIFORM AND EQUIPMENT: TM 8-280

TOOLS, EQUIPMENT, AND MATERIALS: M 38-520-115-1 issued at beginning of 4th hour (one each per student)

PERSONNEL: One instructor (MOS 91P20H or 91P4H)

INSTRUCTIONAL AIDS: Radiographs of the digestive system; one set of cholangiography radiographs; samples of contrast media.

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Lecture

FIRST THROUGH THIRD HOURS

I. INTRODUCTION (5 min)

A. Opening Statement: From the beginning of this course most of you have been anxious to find out something about fluoroscopy. Some may have had experience already and want to know the how and why of the procedures. In every X-ray clinic, at least 4 hours each day are devoted to fluoroscopic examinations of the digestive system. During this hour and the 4 hours to follow we will discuss in detail the methods used and the specialist's part in these examinations.

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*This lesson plan supersedes LP 38-520-115, 100.

1400

B. Objectives

1. Identify the anatomy involved with each examination of the esophagus, stomach, small bowel, and large bowel.

2. State patient preparation procedures for examinations of the esophagus, stomach, small bowel, and large bowel.

3. List exposure room preparation procedure for examinations of the esophagus, stomach, small bowel, and large bowel.

4. State contrast media in proper ratios for examinations of the esophagus, stomach, small bowel, and large bowel.

5. List the methods of introduction of contrast media for examination of the esophagus, stomach, small bowel, and large bowel.

6. Given a radiograph, identify by name the anatomical structures demonstrated and the specific examinations of the esophagus, stomach, small bowel, and large bowel.

7. Assist the radiologist during examinations of the alimentary tract.

C. Class Procedure and Lesson Tie-in.

None

II. EXPLANATION (120)

A. Review Anatomy: Mouth Through Esophagus

1. Mouth--buccal cavity (food masticated and insalivated)

2. Salivary glands

   a. Submaxillary

   b. Sublingual

   c. Parotid

3. Pharynx

4. Esophagus

   a. Ten inches long, posterior to trachea

b. Enters stomach at cardiac orifice

QUESTION: What is the esophagus and where is it located?

ANSWER: The esophagus is a musculomenbranous tube about ten inches long situated between the pharynx and the cardiac orifice of the stomach.

B. Barium Swallow - Esophagram

1. Definition: Fluoroscopic and radiographic examination of the esophagus made visible by the introduction of a contrast media.

2. Purpose

   a. Cancer

   b. Aneurysms

   c. Strictures

   d. Diverticulum

   e. Cardiac size

   f. Hiatus hernia

   g. Foreign objects (cotton balls and barium)

3. Patient Preparation

   a. Scheduled examination

   b. Diet restrictions (Withhold meal prior to exam)

   c. Patient dress (gown)

4. Fluoroscopic room setup

   a. Table upright

   b. Footrest in place

   c. Fluoroscopic screen in place with supply of spot films

   d. Radiographic tube out of way

   e. Bucky tray at foot of table

1402

f. Factors set on control panel

g. Dark adaption

(1) Necessary for conventional unit

(2) Not necessary if image intensification or TV monitor is used

h. Contrast Media

NOTE: Instructor will state barium ratios with barium first and water second.

(1) Barium to water mixture (ratio) 6:1 thick paste

(2) Esophatrast

(3) Temperature (cool)

5. Fluoroscopic examination

a. Patient position

NOTE: Instructor will have one of the students act as patient and will demonstrate fluoroscopic procedure.

b. Preliminary screening

c. Medium introduction (oral)

d. Fluoroscopic survey--spot films

6. Radiographic examination

a. Positions--upright with barium paste

b. Exposure procedure--proper timing

7. Variations

a. Infants

(1) Thin mixture 2:1 ratio

(2) Introduced-baby bottle with enlarged hole in nipple

(3) Immobilization

(4) Short exposure time

b. Children

(1) Forced introduction of medium if necessary

(2) Immobilization

(3) Short exposure time

c. Cardiac Series (Routine chest views plus an LAO to outline the heart)

QUESTION: What is the ratio of barium-to-water mixture used for an esophagus examination of an infant?

ANSWER: 2 to 1.

QUESTION: Who is responsible for determing the dosage of contrast media used in each special examination?

ANSWER: Radiologist

QUESTION: What is the ratio of barium mixture used for an adult esophagram?

ANSWER: Thick past 6:1 (Cool)

QUESTION: What are the two primary examinations of this area?

ANSWER: Barium swallow, esophagram.

C. Review Anatomy: Stomach through Ileocecal Valve

1. Stomach

a. Cardiac orifice

b. Fundus-air

c. Body--greater and lesser curvatures

d. Pyloris

e. Pyloric orifice

2. Small intestine
    a. Duodenal and duodenal bulb—10 inches
    b. Jejunum—8 feet
    c. Ileum—15 feet
3. Ileocecal value

QUESTION: What are the parts of the small intestine, in proper order?

ANSWER: Duodenum, jejunum, and ileum.

D. Upper G. I. Series--Barium Meal

1. Definition-Fluoroscopic and Radiographic examination of the stomach and duodenal cap.
2. Purpose
    a. Ulcers
    b. Cancer
    c. Function
    d. Strictures
    e. Diverticulum
    f. Polyps
3. Patient preparation
    a. Schduled examination
    b. Diet restrictions—NPO 12 hours prior
    c. Patient dress (Gown)

QUESTION: In preparation for an UGI examination, the patient should:

ANSWER: Be NPO at least 12 hours.

1405

4. Fluoroscopic room setup
    a. Table upright
    b. Footrest in place
    c. Factors set on control panel
    d. Fluoroscopic screen in place with supply of spot films
    e. Radiographic tube out of the way
    f. Bucky tray at foot of table
    g. Dark adaption

NOTE: Dark adaptation not necessary if image intensification or TV monitor used.

    h. Contrast Media
        (1) Barium to water mixture (ratio) 1:1
        (2) Temperature (cool)

5. Fluoroscopic examination
    a. Patient position

NOTE: Instructor will have one of the students act as patient and will demonstrate fluorscopic procedure.

    b. Preliminary screening
    c. Medium introduction (oral)
    d. Patient instruction
    e. Vertical study
    f. Horizontal study
    g. Conclusion—mark duodenal bulb

NOTE: Explain use of grid, pressure cone on fluoroscopic assembly.

QUESTION: The appearance of the "shadow" demonstrating air in the stomach will show up as follows:

ANSWER: Light on Fluoroscope and dark on film

QUESTION: After a patient ingests a prepared contrast medium (e.g., BASO4) the stomach shadow will appear as follows:

ANSWER: Light on Film and Dark on fluoroscopic screen.

6. Radiographic examination
   a. Positions-vertical and horizontal
   b. Exposure procedure-proper timing
7. Variations
   a. Small bowel series (Follow-up from UGI Series)
   b. Periodic radiographs of small bowel
   c. Re-fluoroscope patient if necessary (as dictated by radiologist)

NOTE: Instructor will show radiographs of upper G.I. series and small bowel series.

QUESTION: What is the ratio of barium mixture for this examination?

ANSWER: Cold 1:1

QUESTION: What are two names used to describe this examination?

ANSWER: Barium meal and upper G. I. series.

E. Review Anatomy: Ileocecal Valve Through Anus
   1. Ileocecal vlave
   2. Cecum and appendix
   3. Ascending colon
   4. Hepatic flexure
   5. Transverse colon

1407

6. Splenic flexure (left colic flexure)
7. Descending colon
8. Signoid colon (pelvic colon)
9. Rectum
10. Anus

QUESTION: The parts of the large intestine, in proper order are:

ANSWER: Cecum, appendix, colon, rectum, and the anal canal which terminates with the anus.

F. Barium Enema-Colon Series - Large Bowel Series

1. Definition-Fluoroscopic and radiographic examination of the colon, made visible by means of introducing a contrast media.
2. Purpose
   a. Diverticulum
   b. Cancer
   c. Colitis
   d. Polyps

QUESTION: Where are polyps usually found?

ANSWER In the colon.

3. Patient preparation
   a. Scheduled examination
   b. Diet restrictions--NPO 24 hours prior
   c. Colon clerance--laxative and cleansing enemas
   d. Patient dress (gown)

QUESTION: Why is colon clearance so important in a barium enema examination?

ANSWER: So the entire colon may be filled and allow viewing of the entire barium-filled colon.

1406

4. Fluoroscopic room setup
    a. Table horizontal
    b. Sheet on table
    c. Fluoroscopic screen in place with supply of spot films
    d. Radiographic tube out of the way
    e. Bucky at foot of the table
    f. Enema equipment properly assembled
    g. Factors set on control panel
    h. Dark adaption

NOTE: Not necessary if image intensification or TV monitor is used.

    i. Contrast Media
        (1) Barium to water mixture (ratio) 1:8 (thin mixture)
        (2) Temperature (Body temp. 98.6)
        (3) Additives (gum acacia and tannic acid)(only with BASO4)

5. Fluoroscopic examination
    a. Starting position
    b. Enema catheter insertion (lubricant)
    c. Position of enema can
    d. Preliminary screening
    e. Introduction of medium-control of flow
    f. Fluoroscopic study
    g. Maintaining catheter insertion (Bardex, etc)

6. Radiographic examination
    a. Removal of enema catheter

1409

   b. Pre-evacuation film

   c. Post-evacuation film

7. Variations - Double contrast enema

   a. Barium and air

   b. Followup films

QUESTION: The radiologist asks for an air contrast barium enema. When is the air normally introduced?

ANSWER: After the patient has evacuated most of the barium.

NOTE: High kilovoltage technique in excess of 100 KVP would most likely be employed for large bowel studies, for better contrast.

NOTE: Explain the various methods and types of equipment used. (i.e. enema tip, irrigator stand, enema can, K-Y jelly, pneumo-insufflator, etc.)

G. Questions From Students

NOTE: Study Assignment: TM 8-280, pp. 14-1 thru 14-17

III. SUMMARY (10 min)

A. Review of Main Points

1. Anatomy of alimentary tract
2. Patient preparation
3. Fluoroscopic room setup
4. Fluoroscopic examination
5. Radiographic examination
6. Variations

B. Closing Statement: The X-ray Specialist, knowledgeable and proficient in the performance of his duties in fluoroscopy, will greatly assist the radiologist in making an accurate and expedient diagnosis.

1410

LP 38-520-115
105

FOURTH AND FIFTH HOUR

I. INTRODUCTION (5 min)

A. Opening Statement: As an X-ray Specialist, you will be required to perform radiographic examinations of the gallbladder and common duct. These examinations are common to all X-ray Clinics, large and small, and require a specialized knowledge of location and action of these organs in order to obtain a diagnostic set of films.

B. Objectives

1. State the two primary factors which determine a decubitus position.

2. Identify the anatomy involved with each examination of the gallbladder and biliary system.

3. State patient preparation procedures for examination of the gallbladder and biliary system.

4. List exposure room preparation procedure for examinations of the gallbladder and biliary system.

5. State contrast media and method of introduction used for examinations of the gallbladder and biliary system.

6. Given a radiograph, identify by name the anatomical structures demonstrated and the specific examination of the gallbladder and biliary system.

II. EXPLANATION (80 min)

A. Review Anatomy: Gallbladder and biliary system.

1. Gallbladder

2. Cystic duct

3. Hepatic duct

4. Common bile duct

5. Pancreatic duct

6. Ampulla of vater

7. Sphincter of Oddi

1409

NOTE: The right and left hepatic duct joins to form the hepatic duct.

NOTE: The name of the duct extending from the gallbladder to the common duct is the: Cystic duct.

B. Decubitus Views

1. Definition - patient lying down with CR horizontal perpendicular

2. Position

   a. Film placement - perpendicular to table in front or back of either side of patient.

   b. Central ray - horizontal perpendicular

   c. ID placement - normally top border with arrow pointing up

   d. Terminology

      (1) PA right lateral decubitus - Kirkland's view

      (2) Supine, Right lateral decubitus

      (3) AP left lateral decubitus

      (4) Supine, left lateral decubitus

NOTE: Name the position, the way the patient lies down.

3. Purpose

   a. Free air

   b. Fluid levels

NOTE: Two factors always remain the same in decubitus positions. The patient is lying down, and the CR is horizontal perpendicular.

NOTE: Show radiographs of decubitus views

C. Cholecystography

1. Definition - radiographic examination of the gallbladder by means of a contrast medium which may be administered orally or intravenously.

1412

LP 38-520-115
105

2. Purpose

   a. Stones

   b. Function or nonfunction

   c. Inflammation - cholecystitis

3. Location - midway between the vertebral column and lateral aspect of the right side of body at the level of 11th rib.

   a. Hypersthenic - stocky

   b. Sthenic - average

   c. Hyposthenic - slender

4. Patient preparation

   a. Scheduled examination

   b. Diet restriction

      (1) No fats after noon day prior

      (2) NPO after 2400 hours

   c. Contrast Medium

      (1) Telepaque - tablets

      (2) Orally - normally 12 hours prior to exam (1 every 5 minutes)

5. Radiographic exposures

   a. Scout - 14x17 PA

   b. LAO - 8x10

   c. PA Upright - 8x10

   d. Fatty Meal - 8x10 taken 30 minutes after fatty meal.

NOTE: No fatty meal if stones are present, because of pain and aggravation.

   e. Kirkland's - 8x10 PA right lateral decubitus (optional)

6. Failure of Gallbladder to appear
    a. Improper patient preparation
    b. Loss of media - vomiting or diarrhea
    c. Functional disturbance
        (1) Obstruction
        (2) Hepatitis
        (3) Fatty foods eaten
        (4) Stone in hepatic or cystic duct
    d. Previous removal
    e. Didn't take pills

NOTE: Show radiographs of the gallbladder.

QUESTION: If multiple examinations were ordered on a patient to be done on the same day, in what order would a Specialist do a BE, UGI, and GB?

ANSWER: GB, BE, and UGI.

D. Cholangiogram

1. Definition - radiographic examination of the biliary system by means of a contrast media.
2. Purpose
    a. Calculi
    b. Strictures or dilation
3. Methods - OR operative and OR immediate

NOTE: One of the primary purposes is to check for blockage of the biliary system, during a gallbladder operation.

4. Patient preparation
    a. Scheduled examination
    b. Patient anesthetized - operating room, sterile technique

c. Contrast media

(1) Hypaque 35%

(2) T-tube-direct

NOTE: Leave T-tube and thru-out patient's recovery take bile samples and check with post-op films in clinic.

E. Cholangiogram - intravenous - IVC

NOTE: After surgery, several months later or years a problem develops, and IVC cholangiogram is done.

1. Definition - radiographic examination of the biliary system by means of a contrast media.

2. Purpose - check for blockage of the biliary system.

3. Patient preparation

a. Scheduled examination

b. NPO 18 hours day prior to examination

c. Allergy test

d. Contrast media - cholografin

e. Exposure Procedures

(1) 1st hour - every 10 minutes

(2) 2nd hour - every 20 minutes

QUESTION: What is the contrast medium used for an IV Cholangiogram

ANSWER: Cholografin

F. Questions From Students

NOTE: Make Assignment: After class read TM 8-280, pp 14-1 thru 14-17

III. SUMMARY (5 min)

A. Review of Main Points

1. Anatomy of Gallbladder and Biliary System

2. Patient preparation

3. Radiographic examinations

4. Decubitus positions

B. Closing Statement: Gallbladder examinations, cholangiograms, and decubitus views of different parts of the body are accomplished regularly in Army X-ray Clinics. As future X-ray Specialists, it is imperative that you function properly in these areas.

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*IM 38-520-115
105

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DIVISION OF MEDICINE & SURGERY
X-RAY BRANCH

Examination of the Digestive System

From the beginning of this course most of you have been anxious to find out something about fluoroscopy. Some may have had experience already and want to know the how and why of the procedures. In every X-ray clinic, at least 4 hours each day are devoted to fluoroscopic examination of the digestive system. During this hour, and the 4 hours to follow, we will discuss in detail the methods used and the specialist's part in this examination.

The primary purpose of the digestive system is the digestion of food, by chemical and physical means, into forms which can be used by the body for nutritional value. There are two terms which may be used in reference to the digestive system: the alimentary tract and the gastrointestinal tract. The alimentary tract is the term used to indicate the digestive system from the oral cavity to the anus. The gastrointestinal tract refers only to the stomach and intestines.

A brief trace of the digestive tract would begin at the oral cavity. This cavity has three parts; the mouth or buccal cavity, the oral pharynx, and the larynx.

When food, or in our case, barium, leaves the oral cavity, it empties into the esophagus. The esophagus is approximately 10 inches in length and lies immediately posterior to the trachea. It penetrates the diaphragm and enters the stomach by way of the cardiac orifice.

The stomach lies between the esophagus and the small intestines. It is made up of four divisions and two curvatures. These four portions of the stomach are the cardiac portion or superior portion of the stomach, the fundus or that portion of the stomach which contains air, the body or main portion of the stomach, and the pylorus or the inferior portion of the stomach. The two curvatures of the stomach are called the greater and lesser curvatures. The stomach empties into the small intestines by way of the pyloric orifice.

The small intestine is divided into three parts. The first of these parts is called the duodenum. The duodenum is approximately 8 to 10 inches in length. The next section, the jejunum, is the middle portion and is about 8 feet long. The lower portion, the ileum, is about 15 to 18 feet in length and empties into the large intestine by way of the ileocecal valve.

The large intestine, or colon, is about 5 to 6 feet long, and is made up of nine parts. These are the cecum or blind pouch, the ascending colon, the hepatic flexure (where the colon touches the transverse colon, the splenic flexure (where the colon touches the

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*This instructor's manuscript supersedes IM 38-520-115, 100

spleen), the descending colon, the sigmoid colon or the S-shaped portion, the rectum, and the anus.

A barium swallow is a thick paste-like mixture of barium, administered orally, and used for the examination of the esophagus only. Radiographs associated with this examination are called esophagrams.

The patient for an esophagram has been told previously to report to the X-ray clinic at a specific time. The patient has also been told that he may have a light meal prior to reporting for the examination. When the patient arrives at the clinic, he is dressed in an OR gown.

The clinical preparation for an esophagram is accomplished before the arrival of the patient. The paste barium mixture is prepared; the specialist then prepares the fluoroscopic room for an upright examination. The footrest is placed in position, the table is elevated, spot film in place and over the table, tube is out of the way. After the room has been set up, both the specialist and the radiologist establish dark adaptation.

The fluoroscopic examinations begin with a preliminary screening of the patient by the radiologist. The patient stands between the fluoroscopic screen and the table with the right anterior aspect of his body towards the fluoroscopic screen. The specialist hands the patient a spoonful of the paste. At a given signal, the patient puts the barium into his mouth and retains it until the radiologist instructs him to swallow it. The radiologist will then follow the medium as it passes through the esophagus by the use of the fluoroscopic screen. After completion of the fluoroscopic examination, the specialist will make the radiographic examination of the esophagus.

Usually upright oblique views are made employing the cassette changer and 14- by 17-inch films. The specific oblique views to be used will be at the discretion of the radiologist; however, the PARO position is most often used.

The patient is given a spoonful of paste to be taken into his mouth and retained. After instructing the patient to swallow the medium, the specialist can then count to three before making his exposure. The time delay is necessary to allow the contrast medium to distribute through the esophagus. This time interval will vary as to the dictates of the radiologist or as to the prevailing circumstances.

A barium meal is an examination of the esophagus, stomach, and small bowel by means of an oral administration of a contrast medium. This examination is often called an upper G.I. series or a gastrointestinal series.

The patient for a G.I. series has been told to report to the X-ray clinic at a specific time. The patient has been told not to eat or drink anything for 12 hours prior to reporting to the X-ray clinic. When the patient arrives at the clinic he will dress in an OR gown.

Prior to the arrival of the patient, the barium meal should be prepared and the fluoroscopic room should be set up for a G.I. series.

The barium is prepared by mixing one part of barium to one part of water. This is poured into glasses which will be given to the patient.

The fluoroscopic room is arranged with the footrest on the table and the table in the upright position. The overhead tube must be out of the way, and the spot film must be placed in its proper position.

After all has been prepared, both the specialist and the radiologist accomplish dark adaptation. This is accomplished by sitting in a blackened room for 20 to 30 minutes.

When the patient is ready for the examination, he is ushered into the fluoroscopic room and placed on the table with footrest facing the fluoroscopic screen. The radiologist will make a preliminary screening of the patient's lung fields, mediastinum, diaphragm, and heart shadows.

After preliminary screening is finished, the patient is given a glass of the prepared barium mixture and is instructed by the specialist to hold it near the shoulder to avoid contact with the screen. The patient is instructed to swallow a small portion of the barium. The radiologist follows the passage of the barium through the esophagus into the stomach.

Then the radiologist instructs the patient to swallow the remaining barium in the glass. The radiologist then watches the filling of the stomach and the duodenal cap. In any instance where the radiologist suspects pathology, he will take spot films of this area.

Upon completion of the initial examination, the patient is lowered to a horizontal position and is then obliqued with his right side next to the table. The radiologist fluoroscopes the stomach and duodenal cap with the patient in this position. When the radiologist has completed this examination he will make a mark over the duodenal cap with a skin-marking pencil for the specialist to use for a centering reference for the X-ray examination. Usually the radiologist and the specialist have a prearranged system so that the same oblique that was used for fluoroscopic work is maintained for the X-ray examination.

The X-ray examination is governed by the dictates of the radiologist. The number of views to be taken and the specific views to be taken may vary with each individual case.

After the completion of the X-rays, the patient may be told to return to the clinic at a specified time for an additional X-ray. This film is called the "emptying" or "retention" film. It is taken to see what amount of barium sulfate has been emptied or retained in the intestinal tract. The diet restrictions may be removed depending on the specific case.

Occasionally, a series of radiographs may be taken to observe peristaltic movements of the small intestines. This is called a small bowel series. It is performed exactly as the G.I. series with one exception. After completion of the fluoroscopic and radiographic examination, a series of X-rays are taken at regular time intervals of the abdomen. The time intervals for these films are determined by the radiologist and marked on the radiograph by the technologist.

A barium enema is an examination of the large intestines by means of a rectal introduction of the contrast media. This examination is also called a B.E. or lower G.I. series.

The patient for a barium enema examination has been told to report to the X-ray clinic at a specific time. The patient has been informed not to eat or drink anything 24 hours prior to the examination. The night before the examination the patient is given a laxative, and 1 to 3 hours before the examination the patient is administered cleansing enemas until the return is clear. Upon arrival at the clinic, the patient is dressed in an OR gown.

Before arrival of the patient, the fluoroscopic room is prepared. The room is set up for routine fluoroscopy with the table in the horizontal position. One quart of the barium mixture is prepared in ratio of one part barium to eight parts water and is poured into an enema can. Very often a supplement is added to the barium to make the solution more adherent to the lumen of the intestines. This is usually gum acacia.

An enema tube with tip attached is connected to the enema can and a preliminary test is made to check for continuous flow of the solution as well as the removal of air from the tubing. Vaseline or a like product is then applied to the tip, which is then wrapped in gauze until the time of examination.

When all preparation is complete, both specialist and radiologist acquire dark adaptation. The patient is then called into the fluoroscopic room and is placed in a lateral recumbent position on the X-ray table with the uppermost leg moved forward. The specialist then inserts the enema tip. The enema can is raised above the level of the patient and placed on an enema rack.

1420

As soon as the specialist has everything ready, the radiologist will make a preliminary screening and then instruct the specialist to begin the flow of barium. The amount of barium to be used and the rate of flow of the suspension will be directed by the radiologist.

Upon completion of the fluoroscopic examination, the specialist will make radiographs of the patient. The enema tip will be removed before these radiographs are taken and the patient should be advised to retain the barium. The positions to be taken are those desired by the radiologist and will usually be accomplished on 14- by 17-inch films. When filming is completed, the specialist will show the patient to the latrine and allow the patient to evacuate the barium.

In certain cases the radiologist has the patient return after evacuation in order that air may be introduced into the colon. This particular study is called a double contrast barium enema.

In cases where air contrast is not used, the patient will return after evacuation for one more X-ray. This final radiograph is called the postevacuation film.

The X-ray specialist, knowledgeable and proficient in the performance of his duties in fluoroscopy, will greatly assist the radiologist in making an accurate and expedient diagnosis.

As an X-ray specialist, you will be required to perform radiographic examinations of the gallbladder and common duct. These examinations are common to all X-ray clinics, large and small, and require a specialized knowledge of location and action of these organs in order to obtain a diagnostic set of films.

The term decubitus means lying down. In radiography, decubitus means that the patient is lying down and that the central ray is horizontal. Despite what condition is to be demonstrated these two things must be so in a decubitus position: the patient must be lying down and the central ray must be horizontal.

There are four ways that a person can lie down: He can rest upon his stomach or his back, or he must lie down upon either side. To say that a person can lie prone, supine, on his left side, or on his right side, is to start the terminology of a decubitus position. This body position must be combined with the view desired, PA, AP, or lateral, in order to fully describe a decubitus position.

In other words, if a person is to lie upon his side for a decubitus position, then we will get either a PA or AP view of the part depending upon desires or dictates. With a horizontal central ray this must be so. Similarly, if a person lies upon his stomach or back, we will get a lateral view of the part. Oftentimes the terms "transabdominal" or "transchest" will be associated with this particular decubitus view.

Decubitus terminology answers the question, how is the patient lying down? There is no mistake when called upon to take a PA view of the part with the patient in a left lateral decubitus position. The patient is on his left side and we employ a horizontal central to get a PA view of the part. To get a left lateral view of supine decubitus, the patient is on his back, film at left side, and we employ a horizontal central ray.

There are many clinical applications of decubitus positions although you may not hear them called by that name. Right lateral decubitus with a PA view is a great aid in demonstrations of stones and moving the gallbladder away from the spine in cholecystography. Minimal movement of the patient and part will be assured when doing decubitus positions of the skull and spine.

Decubitus is also gainfully employed in the demonstration of certain conditions of free air and free fluid within a given area. Remember that free air will always rise; free fluid will go downward. Knowing the effect desired, you can select the proper position if that is not requested. On either fluid or air, allow the patient to lie in the given position for several minutes before making the exposure. This will allow either vehicle to go where or in the direction you want it to go.

The terminology of decubitus you have; now for the factor technic. Follow the factor chart for a normal view of the part. Use a stationary grid or a portable Bucky of parts calling for a Bucky. Compensate for limited FFD. Regardless of desired demonstration, ID's are usually along the lateral border of the cassette. On lateral decubitus positions (PA or AP views of part), an arrow marker is placed with a letter marker to indicate the side nearest the film. However, the arrow marker could be used on the supine or prone decubitus to indicate the aspect of the body that is up.

When you hear new words for the first time, it may be easier for you to understand them if you will break compound words into separate components. "Chole" refers to bile or gall, "cyst" refers to bladder, and "ography" to a writing or study; therefore, a cholecytography is the radiographic examination of the gallbladder by means of a contrast medium which may be administered orally or intravenously.

The purpose of cholecystography is to determine if there is any pathology in or surrounding the gallbladder. Malfunction of the gallbladder, negative or radiolucent stones, and tumor masses that alter the size or shape of the gallbladder can be demonstrated.

The gallbladder, which is located on the under surface of the liver, stores and concentrates the bile until nerve impulses create a contraction to expel the bile into the duodenum to aid in the digestion of fatty food.

When there is suspected pathology in or around the gallbladder and the physician determines a need for a gallbladder examination, the patient will be given a request slip, sent to the X-ray clinic, and then scheduled according to clinical policy.

Actual clinical routines vary according to the wishes of the radiologist, but the following composite routine will enable you to adapt to the procedure used in your new clinic.

The afternoon prior to the examination, the patient may be required to report to the clinic for a preliminary survey film of the abdomen. Approximately 2 hours before the evening meal, a laxative or a cleansing enema is administered. The evening meal should be eaten at 1700 hours and will be light and fat-free.

When using one of the oral contrast mediums, Priodax or Telapaque, the patient will take one pill followed by a half glass of water every 5 minutes with the first pill to be taken at 1800 hours. After taking the pills, the patient may drink water until bedtime, but he cannot take anything else until directed on the morning of the examination.

When the contrast medium is to be injected intravenously, 4 hours prior to the scout film in the morning, a medium such as sodium tetraiodophenolphthalein or a commercially prepared medium such as Cholografin or Biligrafin will be given the patient. Sensitivity tests will be run on the patient and more care will be needed because of the greater toxicity and decreased patient tolerance to the intravenous injection.

The patient will report to the X-ray clinic at the scheduled time and will be suitably gowned and prepared for the films. A scout film must be taken to show the general condition of the abdomen, the effectiveness of the enema or laxative, degree of visibility of the gallbladder, and the exact location in relation to known body landmarks. The exact position of the gallbladder may be as high as the 10th rib posteriorly or as low as the iliac fossa. In general, in the sthenic or average build of patient, the gallbladder will be found near the level of the middle of the 11th rib. In the hypersthenic or stocky built patient, the gallbladder will be higher, and in the hyposthenic or slender patient, lower. Usually, the scout will be centered at or near the 11th rib, will be processed immediately, and checked while it is still wet. The position of the gallbladder will be determined and a mark placed on the patient's back to aid in the centering of coned-down followup films.

Using the mark as a reference, a coned view will be made in the left anterior oblique position to project the gallbladder away from the transverse processes of the vertebrae and to give a slightly different view of the gallbladder. An upright view will also be taken to demonstrate multiple small radiolucent stones. Depending upon their specific gravity, these stones will either float on the bile or sink into the fundus and form strata which could be demonstrated on film.

These films will be processed and all films will be shown to the radiologist who will determine if other films are needed. Some of the other views would be those to move the gallbladder away from the hepatic flexure of the colon. The most common would be a right lateral decubitus, PA view, coned-down. Occasionally, a modified Trendelenburg or some other position will be made according to the wishes of the radiologist.

After these films have been taken and examined the patient will be sent out for a fatty meal unless otherwise indicated by the radiologist. This fatty meal will usually consist of eggs, well-buttered toast, heavily creamed coffee, ham or bacon, and similar types of fatty foods. Some clinics are using commercially prepared substitutes in lieu of the fatty meal. Some obvious advantages are the ease and convenience of administration, speed, and a known fat content.

After waiting the specified time, a postfatty meal film will be taken to determine if the gallbladder is functioning properly. If it is functioning properly, the fat will have caused the gallbladder to contract, expelling the contrast media loaded bile so that the resultant film will show a much smaller appearing gallbladder.

If the gallbladder failed to appear in the scout film, try to find out the reason by tactful questioning. The oral media sometimes cause gastrointestinal upset and the resultant diarrhea or vomiting may cause the medium to be expelled before a sufficient quantity has entered the bloodstream. If this has happened the radiologist will reschedule the patient and prescribe some type of medication to quiet the gastrointestinal upset caused by the pills.

Functional disturbance will cause a gallbladder to fail to appear, or sometimes a patient will neglect to inform the physician that his gallbladder has been removed.

Whatever the cause of the failure of the gallbladder to appear, the film and patient will be taken to the radiologist and he will give you instructions as to the disposition of the patient.

Cholangiography is another compound word. Chole refers to bile, angio refers to vessel, graphy to study; so we have a bile vessel study. Cholangiography is a radiographic examination of the biliary system by means of a contrast media. This examination is used to determine the potency of the common bile duct, the status of the sphincter of Oddi, to reveal the presence of calculi within the ducts, to interpret strictures or dilation, and to diagnose any biliary fistulae.

The hepatic ducts originate deep within the lobes of the liver, and the many smaller ducts join to form larger ducts until there are only the right and left hepatic ducts which join to form the common hepatic duct. This duct, below the junction of the cystic duct from the gallbladder, becomes the common bile duct and empties into the duodenum.

There are two principal methods of administering the contrast media: direct, which can be either operative or postoperative, and intravenous.

Operative or immediate cholangiography will be carried out in surgery under sterile technique. The patient will be anesthetized; the biliary tract exposed by surgical means; and the contrast medium will be injected directly into the ducts with films to be made at the direction of the surgeon.

A high-speed portable Bucky or a film tunnel should be incorporated into the sterile area and placed in the proper position before surgery is begun. An adequate supply of 14- or 17-inch cassettes will be immediately available but protected from stray radiation.

Teamwork and precise timing are very important in this examination. The patient will be covered with a sterile drape so the surgeon will indicate the exact point to direct the central ray. When you have your film in place and your machine ready, a contrast medium such as Hypaque or Hippuran will be injected into the biliary ducts and you will make your exposure on a signal from the surgeon. Care must be taken to make certain that no surgical instruments will be superimposed over the area of interest. All films will be processed immediately and returned to the surgeon for viewing. This examination is frequently performed in conjunction with cholecystectomy.

Postoperative or delayed cholangiography will be accomplished within 14 days of surgery; and since no anesthesia or special preparation is necessary, the patient will be brought to the X-ray clinic.

Following surgical removal of the gallbladder, a "T" tube will be left in the common bile duct for drainage. The same type of contrast medium that was used in operative cholangiography will be injected through this tube by a physician. The necessary film will be made as directed by the physician and will be processed immediately for his viewing.

1425

For intravenous cholangiography, the patient will be scheduled and instructed to report at a given time in your clinic and to take nothing by mouth after 1800 hours the day prior to examination.

The morning of the examination, the patient will be given a sensitivity test. If there are no contraindications, 40 cc. of Cholografin will be slowly injected intravenously by a physician. Ten minutes after the injection the first film will be taken, processed immediately, and wet read by the radiologist. The factors used and positioning will be checked by the specialist to make certain that they are correct. During the 1st hour, films will be taken at 10-minute intervals and during the 2d hour at 20-minute intervals. Each film will be wet read by the radiologist. Unless there are variations in positioning requested, this usually completes the examination.

Throughout the entire course of the examination, the patient must be carefully watched for any evidence of reaction due to the administration of the contrast medium.

Gallbladder examinations, cholangiograms, and decubitus views of different parts of the body are accomplished regularly in Army X-ray clinics. As future X-ray specialists, it is imperative that you function properly in these areas.

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036

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE & SURGERY
X-RAY BRANCH

Positioning: Stomach, Duodenum, Barium Enema, and Esophagus (1 hour)

COURSES PRESENTED TO: Radiographic Procedures (Basic) 313-91P20

PLACE: Classroom

REFERENCES:

TM 8-280

STUDY ASSIGNMENT: After class Review: TM 8-280, pp 14-1 to 14-13

STUDENT UNIFORM AND EQUIPMENT: TM 8-280

TOOLS, EQUIPMENT, AND MATERIALS: N/A

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Radiographs of the barium meal, barium enema, and barium swallow; (see Annexes A thru F), pointer and sufficient amount of radiographic illuminators; typical radiographic exposure room; chalkboard, chalk, and eraser.

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

I. INTRODUCTION (2 min)

A. Opening Statement: One of the most common and yet time-consuming x-ray examinations is that of the alimentary tract. It is not uncommon to spend an entire morning performing fluoroscopic and radiographic examinations of the stomach and duodenum. As a military X-Ray Specialist, you must have the ability to perform the complete study of the alimentary tract.

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*This lesson plan supersedes LP 38-520-065, 104

B. Objectives

1. Identify by name the position and anatomical structures demonstrated on the routine and additional views of the stomach, duodenum, barium enema, and esophagus.

2. State the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization, film identification and captioning necessary to demonstrate the positions of the stomach, duodenum, barium enema, and esophagus.

3. Given a request slip and a simulated patient in the x-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiograph of the stomach duodenum, barium enema, and esophagus.

C. Class Procedure and Lesson Tie-in

None

II. EXPLANATION (38 min)

A. Review Anatomy

NOTE: Place radiographs on viewbox and point out the following anatomical structures.

1. Esophagus - 11 inches

2. Stomach

   a. Cardiac orifice

   b. Fundus

   c. Body

   d. Pylorus

   e. Pyloric orifice

   f. Greater curvature

   g. Lesser curvature

1428

3. Small intestines
    a. Duodenum--8 to 10 inches in length
    b. Jejunum--7 to 7½ feet in length
    c. Ileum--15 to 18 feet in length
4. Large intestines--approximately 5 feet
    a. Iliocecal valve
    b. Cecum
    c. Ascending colon
    d. Heptic flexure
    e. Transverse colon
    f. Splenic flexure
    g. Decending colon
    h. Sigmoid colon
    i. Rectum
    j. Anus

B. Explanation--Esophagus

NOTE: See Annexes A, B and C for explanation of positions

1. Purpose of films
    a. Cancer
    b. Strictures
    c. Aneurysms
    d. Cardiac size
    e. Hiatus hernia
    f. Foreign bodies
2. Positions
    a. PA
    b. RAO
    c. Lateral

NOTE: Body rotated 45 degrees for RAO

NOTE: Positions will be demonstrated by instructor using student from class as a patient.

NOTE: See Annexes D and E for explanation of views

C. Explanation--Stomach and Duodenum

1. Purpose of films
   - a. Ulcers
   - b. Cancer
   - c. Function
   - d. Strictures
   - e. Foreign bodies
2. Positions
   - a. Posterior-anterior
   - b. Oblique--right anterior oblique (RAO)

NOTE: Explain that the body is rotated 30 to 45 degrees for oblique.

NOTE: Demonstrate positions using information in para B.

NOTE: Positions will be demonstrated by the instructor using a student from the class as a patient.

QUESTION: What are the routine views for the esophagus?

ANSWER: PA, RAO, and lateral.

QUESTION: What is the degree of oblique for the RAO stomach?

ANSWER: 30 to 45 degrees.

NOTE: See Annex F for explanation of view.

1430

D. Explanation--Barium Enema

1. Purpose of film

   a. Diverticulitis

   b. Cancer

   c. Colitis

   d. Polyps

   e. Postoperative cholecystotomy

NOTE: Demonstrate positions using information in Annexes A thru F.

NOTE: Positions will be demonstrated by the instructor using a student from the class as a patient, time allowing.

E. Explain the Small Bowel Series

1. Time intervals

   a. Periodic radiographs of small bowel (as dictated by Radiologist).

   b. Refluoroscope patient, if necessary (as dictated by Radiologist).

2. Routine views--PA

NOTE: Same position as AP abdomen.

QUESTION: What will the PFR for barium enema be?

ANSWER: Iliac crests to center.

F. Questions From Students

NOTE: Study assignment: After class, study TM 8-280, pp 14-1 to 14-13

III. SUMMARY (5 min)

A. Review of Main Points

1. Anatomy

2. Esophagus

3. Stomach and duodenum

1431

4. Barium enema

5. Small bowel series

B. Closing Statement: Unlike most other views taught in this phase of instruction, the preceding, with the possible exception of the barium swallow, are done routinely every day in most large X-Ray Clinics. Therefore, a good working knowledge of these procedures is very important to an X-Ray Specialist.

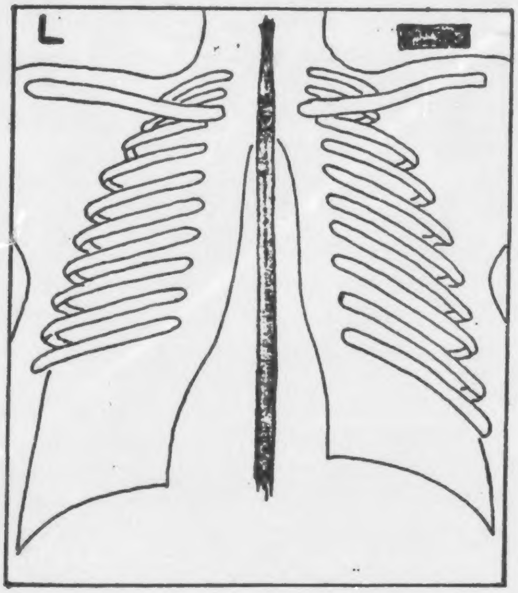
1432

ANNEX A
INSTRUCTIONAL AIDS

LP 38-520-065
036

Esophagus

Esophagus Routine PA, RAO, and Lateral



Esophagus position PA

PFR: Acromion process 4 inches below the upper film border

FRD: 14 by 17 lengthwise, NB ID: Proper correct letter marker

CR: Horizontal perpendicular Cone for Full film coverage

Breathing technique: Suspended inspiration FFD: 72 inches

Demonstrates: Barium filled Esophagus

Alignment: Median plane perpendicular to the center of film and part and centered

Notes: Have patient take one tablespoon of barium mixture and swallow once then a second time, then take a deep breath and hold it; at that point the exposure is taken

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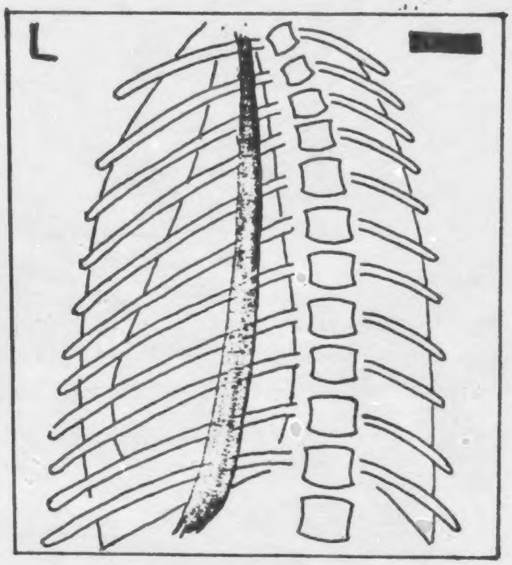
ANNEX B
INSTRUCTIONAL AIDS

Esophagus

Esophagus Routine PA, RAO, and Lateral



Esophagus position RAO

PFR: Acromion process 4 inches below upper film border

FRD: 14 by 17 lenghtwise, NB ID: Proper letter marker

CR: Horizontal perpendicular Cone for full filn coverage

Breathing technique: Suspended inspiration FFD: 72 inches

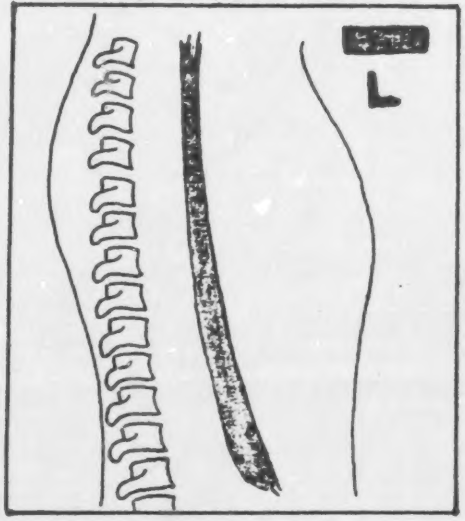
Demonstrates: Barium filled Esophagus

Alignment: Body centered and median plane rotated 45 degrees

Notes: Have patient take one tablespoon of barium mixture and swallow once then a second time, then take a deep breath and hold it; at that point the exposure is taken

Esophagus

Esophagus Routine: PA, RAO, and Lateral



Esophagus position: Lateral

PFR: Acromion process 4 inches below upper film border

FRD: 14 by 17 lengthwise, NB   ID: Proper letter marker

CR: Horizontal perpendicular   Cone for Full film coverage

Breathing technique: Suspended inspiration   FFD: 72 inches

Demonstrates: Barium filled Esophagus

Alignment: Median plane parallel to film and part centered

Notes: Have patient take one tablespoon of barium mixture and swallow once then a second time, then take a deep breath and hold it; at that point the exposure is taken

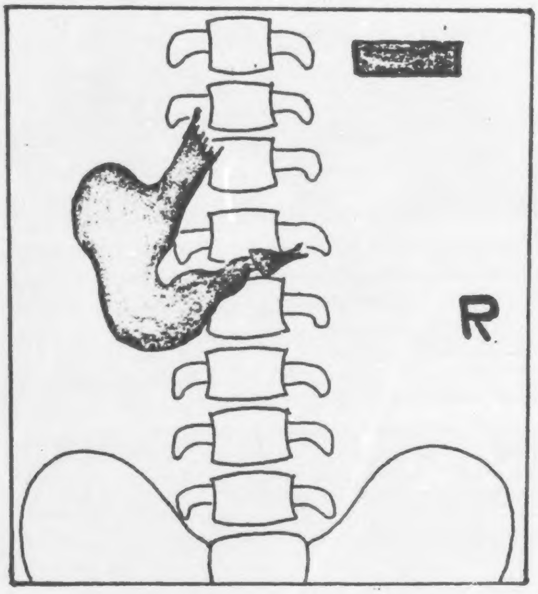
1435

LP 38-520-065
036

ANNEX D
INSTRUCTIONAL AIDS

Stomach

Stomach Routine: PA and RAO



Stomach position: PA

PFR: Iliac crest five inches below center of the film

FRD: 14 by 17 lengthwise, B ID: proper letter marker

CR: Vertical perpendicular Cone for Full film coverage

Breathing technique: Suspended inspiration

Demonstrates: Stomach and duodenum

Alignment: Median plane perpendicular to center of table (part centered)

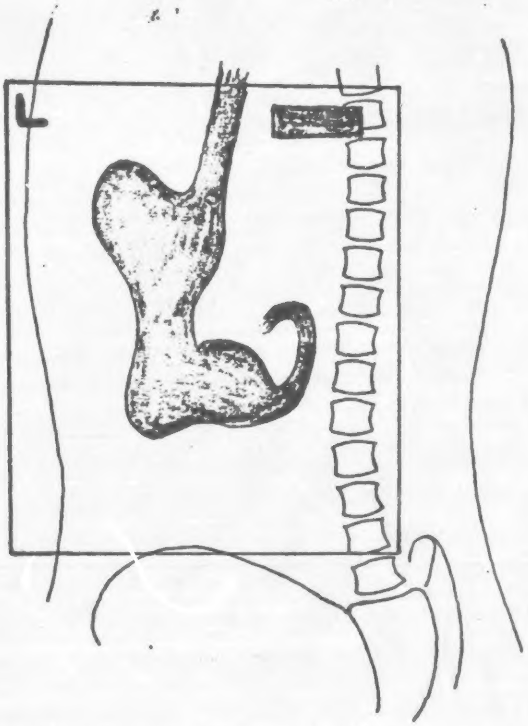
Notes: Stomach should be filled for exposure; have patient drink barium mixture before radiographs are taken

1434

ANNEX E
INSTRUCTIONAL AIDS

Stomach

Stomach Routine: PA and RAO



Stomach position: RAO

PFR: Iliac crest at the level of the lower border of the film

FRD: 10 by 12 lenghtwise, B   ID: Proper letter marker

CR: Vertical perpendicular   Cone for Full film coverage

Breathing technique: Suspended inspiration   FFD: 40 inches

Demonstrates: Stomach and duodenum

Alignment: Body rotated 30 to 45 degrees, midpoint between vertebral column and lateral aspect of the body placed over center of table

Notes: Stomach should be filled for exposure ; have patient drink barium mixture before radiographs are taken

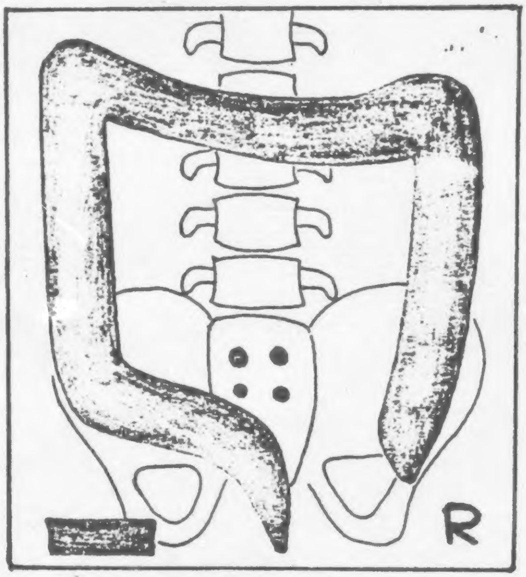
1437

LP 38-520-065
036

ANNEX F
INSTRUCTIONAL AIDS

Barium Enema

Barium Enema Routine: PA or AP, Pre and Post Evac



Barium Enema Positions: PA or AP, Pre and Post Evac

PFR: Iliac crest to center of film

FRD: 14 by 17 lengthwise, B   ID: Proper letter marker

CR: Vertical perpendicular   Cone for Full film coverage

Breathing technique: .Suspended respiration   FFD: 40 inches

Demonstrates: Large intestine

Alignment: Median plane perpendicular to center of film

Notes: AP or PA, Pre and Post may be taken

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046

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE & SURGERY
X-RAY BRANCH

Positioning: Gallbladder (1 hour)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES: TM 8-280

STUDY ASSIGNMENT: After class Review TM 8-280, pp 14-14 to 14-16.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280

TOOLS, EQUIPMENT, AND MATERIALS: None

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Radiographs of the gallbladder, radiographic illuminators, pointer, typical radiographic exposure room (see Annexes A, B, and C); Chalkboard, chalk, and eraser

TROOP REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

I. INTRODUCTION (2 min)

A. Opening Statement: Most examinations which must be scheduled are considered to be special examinations. One of these examinations is the gallbladder study. Great care must be taken by the X-ray Specialist to give the patient the correct instructions before and during the examination, make consistently good radiographs, and assist the Radiologist during the examination.

B. Objectives

1. Identify by name the position and anatomical structures demonstrated on the routine and additional views of the gallbladder.

2. State the correct routine, PFR/CRPR, film rundown, conefield, angle and direction of the central ray, FFD, alignment, breathing technique, immobilization, film identification and captioning necessary to demonstrate the positions of the gallbladder.

3. Given a request slip and a simulated patient in the x-ray laboratory, select the proper technical factors, accessory equipment and the correct positioning data which would produce a technically acceptable radiographs of the gallbladder.

This Lesson Plan Supersedes LP 38-520-066, 074

1439

C. Class Procedure and Lesson Tie-in

This one hour block of instruction was preceded by a lecture (LP 38-520-115)

II. EXPLANATION (40 min)

A. Review Anatomy

NOTE: Place radiographs on illuminators and point out the following anatomical structures.

1. Gallbladder
2. Lumbar spine
3. Eleventh rib
4. Approximate position of duodenum

B. Precautions (Nothing fatty by mouth before examination)

C. Routine positions

NOTE: Refer to Annexes A, B, and C for explanation

1. PA scout view

NOTE: Median plane over center line of table

2. LAO view

NOTE: Midpoint of vertebral column and lateral aspect of body at level of 11th rib over center line of table, body rotated 20° to 30°.

NOTE: Use right letter marker, within the cone field.

3. Upright PA view

NOTE: Midpoint between vertebral column and lateral aspect of body, 2" below the level of the 11th rib to center of table.

NOTE: Use right letter marker in conefield, and indicate upright with appropiate marker.

4. Right lateral decubitus (additional)

NOTE: Patient is in right lateral recumbent position, horizontal perpendicular CR.

NOTE: PFR and FRD are the same as for the LAO view

D. Demonstrate positions using information in Annexes A thru C

1. PA view

NOTE: Positions will be demonstrated using a student selected from class as a patient.

QUESTION: What is the PFR for the LAO gallbladder view?

ANSWER: Midpoint of vertebral column and lateral aspect of body at level of 11th rib over center line of table, body rotated 20° to 30°.

2. LAO view

3. Upright PA view

QUESTION: What is the PFR for the upright PA gallbladder view?

ANSWER: Midpoint between vertebral column and lateral aspect of body, 2" below the level of the 11th rib to center of film.

E. Questions From Students

NOTE: Make assignment: After class study TM 8-280, pp 14-14 thru 14-16.

III. SUMMARY (3 min)

A. Review of Main Points

1. Review anatomy

2. Routine and additional positions

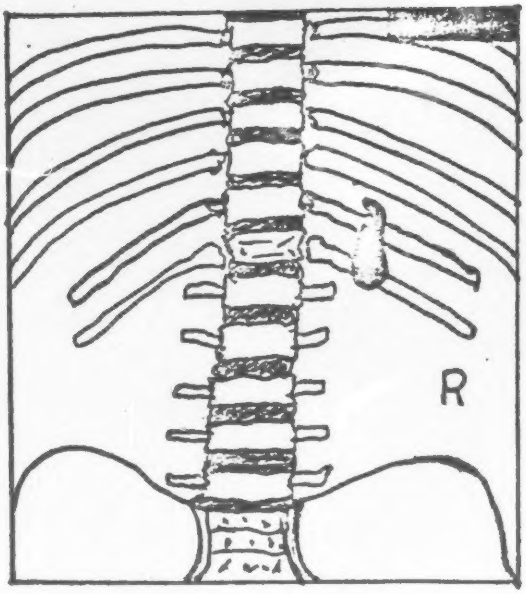
B. Closing Statement: The gallbladder series is a scheduled examination and is considered to be a special examination, because the patient has to have special preparation. It is of utmost importance that you understand how to do the procedures in order to prevent needless time and exposure to both the patient and yourself.

1441

ANNEX A
INSTRUCTIONAL AIDS

Gallbladder

Gallbladder routine: PA Scout, LAO, and Upright PA views



Gallbladder position: PA Scout

PFR: Iliac crest 3 inches below center of film

FRD: 14 x 17, LW, B ID: Flashed in Darkroom

CR: Vertical perpendicular Cone for Full Film Coverage

Breathing technique: Suspended expiration FFD: 40"

Demonstrates: Gallbladder

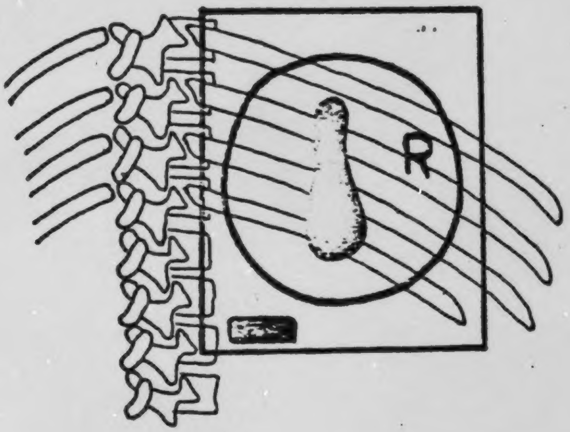
Alignment: Median plane over center line of the table

Notes: Use appropriate letter marker with corresponding side of the body.

1442

Gallbladder

Gallbladder routine: PA Scout, LAO, and Upright PA views



Gallbladder position: LAO

PFR: A point midway between vertebral column and lateral aspect of body at level of 11th rib to center of film

FRD: 8 x 10, LW, B ID: Flashed in Darkroom

CR: Vertical perpendicular Cone for 6"

Breathing technique: Suspended expiration FFD: 40"

Demonstrates: Gallbladder

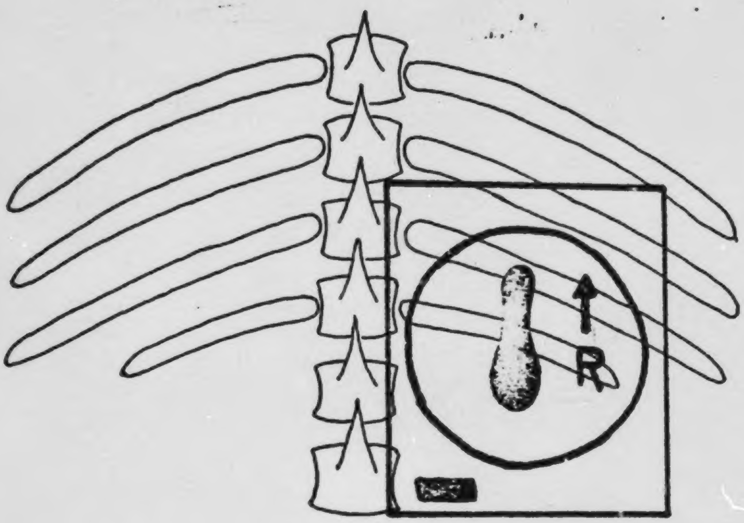
Alignment: Midpoint of vertebral column and lateral aspect of body over center line of the table, body rotated 20° to 30°.

Notes: Use right letter marker, within the conefield.

ANNEX C
INSTRUCTIONAL AIDS

Gallbladder

Gallbladder routine: PA Scout, LAO, and Upright PA views



Gallbladder position: Upright PA

PFR: A point midway between vertebral column and lateral aspect of body 2 inches below level of 11th rib to center of film.

FRD: 8 x 10, LW, B

ID: Flashed in Darkroom

CR: Horizontal perpendicular

Cone for 6"

Breathing technique: Suspended expiration

FFD: 40"

Demonstrates: Gallbladder

Alignment: Align midpoint between vertebral column and lateral aspect of body to center of the table.

Notes: Use (R) letter marker within the conefield, and indicate upright with appropriate marker.

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*LP 38-520-129
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ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE & SURGERY
X-RAY BRANCH

Automatic Processor (1 hour)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES:

TM 8-280, chap 7 Sec G pp 7-41-44.
McKinney, William E. J. Building An Automatic Processor. Wilmington, Delaware: E. I. DuPont de Nemours and Company, Incorporated, 1970, pp 1-17.

STUDY ASSIGNMENT: After class read TM 8-280, pp 7-41-44

STUDENT UNIFORM AND EQUIPMENT: TM 8-280.

TOOLS, EQUIPMENT, AND MATERIALS: M 38-520-129 issued at beginning of class (one per student)

PERSONNEL: One instructor (91P4H or 91P2H)

INSTRUCTIONAL AIDS: 35-mm. carousel projector, screen, and pointer; S 38-520-129-1 thru -22 (see Annex A). Automatic processing check list (See Annex B)

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Lecture

I. INTRODUCTION (3 min)

A. Opening Statement: The field of radiography is becoming more and more automated and mechanized to keep pace with new procedures and ever increasing workloads. Automatic processors have evolved from days of manual processing, through automatic hanger processing to present day hangerless, automatic processors. Automatic processors offer the added benefits of better quality control, faster processing, and it is automatic, compact, and much cleaner in operation. Many people never realize that the automatic processor is composed of several systems. We will look at each system individually and ultimately build our automatic processor system from the standpoint of "Systems Engineering."

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*This Lesson Plan supersedes LP 38-520-129, 1054

1445

B. Objectives

1. Describe and list the seven systems of systems engineering in automatic processing.

2. State the main difference between automatic processing and manual processing.

3. List the precautionary measures and proper maintenance required for the automatic processor.

C. Class Procedure and Lesson Tie-in

None

II. EXPLANATION (37 min)

NOTE: Use and show S 38-520-129-1 stating what class is about, "Systems Engineering." (TM 8-280, Omits Chemistry and Electrical Systems)

A. Systems Engineering

NOTE: Show S 38-520-129-2 showing what makes up "Systems Engineering."

1. Chemistry system

NOTE: Show S 38-520-129-3 and -4 demonstrating chemistry.

a. Function of developer

b. Function of fixer

QUESTION: What is the proper order of processing in the correct sequence in manual processing?

ANSWER: Developer, stopbath, fixer, wash, and dry.

NOTE: The main difference between manual and automatic processing no stop bath and glutaraldehyde added to developer solution to pre-harden film.

NOTE: Show S 38-520-129-5 demonstrating automatic processing.

c. Maintenance and care of tanks

NOTE: Show S 38-520-129-6 showing uncleaned tanks.

2. Tempering system

a. Function of system
   (1) Time
   (2) Temperature

NOTE: Show S 38-520-129-7 demonstrating tempering system.

b. Equipment
   (1) Heating element
   (2) Thermostat

c. Heat exchanger--restrainer

d. Regulation of water
   (1) Volume
   (2) Temperature--5° below desired solution temperature

e. Washing solutions
   (1) Mixing valve
   (2) Thermometer
   (3) Filters
   (4) Flowmeter

NOTE: Show S 38-520-129-8 on mixing valve and thermometer.

3. Transport system

a. Equipment

NOTE: Show S 38-520-129-9 demonstrating roller transport system.

   (1) Feed tray
   (2) Roller banks
   (3) Crossovers
   (4) Microswitch

NOTE: Show S 38-520-129-10 demonstrating different types of roller assemblies.

(5) Drive subsystem

(a) Drive motor

(b) Processor drive shaft

(c) Cog wheels

NOTE: Show S 38-520-129-11 which is a top view of drive subsystem.

b. Function and maintenance of equipment

NOTE: Show S 38-520-129-12 and -13 demonstrating, finally, completion of whole system.

4. Circulation/filtration system

NOTE: Show S 38-520-129-14 of circulation/filtration system.

a. Functions

(1) Provides sufficient agitation

(2) Recirculation of all solutions

(3) To keep chemistries clean

QUESTION: What can be used to keep solutions or chemistries clean?

ANSWER: Filters.

NOTE: Show S 38-520-129-15 which is demonstrating pumps.

5. Replenishment system

NOTE: Show S 38-520-129-16 showing replenishing system.

a. Separate replenisher tanks

QUESTION: What causes oxidation of developer?

ANSWER: Exposure to air.

b. Microswitch

c. Filters

d. Flowmeters

e. Checkpoints

NOTE: Show S 38-520-129-17 demonstrating a typical pump.

6. Air dryer system

NOTE: Show S 38-520-129-18 demonstrating complete system.

a. Blower

b. Heater

c. Exhaust system

NOTE: Show S 38-520-129-19 which is the blower motor.

d. Air tubes

NOTE: Show S 38-520-129-20 demonstrating air tubes.

7. Electrical System

NOTE: Show S 38-520-129-21 demonstrating electrical system.

a. Microswitches

b. Circuit breakers

NOTE: Show S 38-520-129-22 demonstrating fuses and main terminal strip.

B. Finished Assembled Automatic Processor

1. Operation of all systems together

2. Awareness of similarities of all processors

a. Xomat Models M-2, M-4, M-4A, M-6, and M-6-AN

b. Pakorol Models X and XM

C. Automatic Processing-Operating and Maintenance Check List (See Annex B)

NOTE: After class study TM 8-280, chap 26, sec IV, pp 271-275.

1449

LP 38-520-129
046

III. SUMMARY (5 min)

A. Review Main Points

1. Systems engineering

a. Chemistries

b. Temper

c. Transport

d. Circulation/filtration

e. Replenisher system

f. Air/dry system

g. Electrical system

2. Systems together

3. Operating and maintenance check list

B. Closing Statement: During the last hour we have covered the complete systems and functions of the automatic processor. A thorough understanding of the systems of the automatic processor will enable you, as X-ray specialists, to be more efficient in producing x-rays.

ANNEX A
INSTRUCTIONAL AIDS

Slides

S 38-520-129-1	"Systems Engineering"
S 38-520-129-2	Make up of systems engineering
S 38-520-129-3	Chemistry system
S 38-520-129-4	Type of solutions
S 38-520-129-5	Automatic processing with solutions
S 38-520-129-6	Uncleaned solution tanks
S 38-520-129-7	Tempering system
S 38-520-129-8	Mixing valve and thermometer for water
S 38-520-129-9	Roller transport system
S 38-520-129-10	The different types of roller assemblies
S 38-520-129-11	Top view of drive subsystem
S 38-520-129-12	Final completion of roller transport system
S 38-520-129-13	Final completion of roller transport system
S 38-520-129-14	Circulation/filtration system
S 38-520-129-15	Circulation pumps
S 38-520-129-16	Replenishing system
S 38-520-129-17	Replenishing pumps
S 38-520-129-18	Air/dryer system
S 38-520-129-19	Blower motor
S 38-520-129-20	Air tubes
S 38-520-129-21	Electrical system
S 38-520-129-22	Fuses and main terminal strip

Automatic Processing-Operating and Maintenance Check List

OPERATION

STARTING

1. Open wash water and replenisher tank valves.
2. Turn on all switches.
3. Allow 15 minutes developer warm-up.
4. Remove crossovers. Turn sun gear and wipe crossover rollers with damp sponge or cloth. Wipe stainless feed rollers, and top guide plates of developer rack(s).
5. Check solution level in Processor and replenisher storage tanks. Check wash water flow.
6. Check solution filter cartridge(s).
7. Insert film between stainless feed rollers and adjust flowmeters for correct replenishment rate.
8. Reinstall crossovers, and visually check operation of racks and dryer rollers.
9. Be sure all covers and side panels are in place.
10. Run enough clean-up film to clean rollers which are out of solution. Don't re-use clean-up sheets.
11. Be sure developer and wash water have stabilized at proper temperature.

FEEDING FILM

1. Place film on feed table, and push in until rollers pull it forward.
2. When bell sounds, feed another film.

DURING OPERATION

1. Check replenisher and water flow rates occasionally.
2. Check wash water and developer thermometers occasionally.

STOPPING

1. Turn off all switches.
2. Remove crossovers and wipe with damp sponge or cloth. Use a non-metallic pad for stubborn dirt and chemicals.
3. Wipe stainless feed rollers and check that they turn freely, then reinstall crossovers.
4. Clean the dryer rollers.
5. Flush out sink below solution tanks.
6. Wipe up chemical deposits on machine.
7. Turn off wash water.
8. To prevent rusting, leave dryer and processor covers open slightly when machine isn't running.

STANDBY POSITION

For emergency work at night, or slack periods during the day, leave only heat and cool switches on. Then, when other switches are turned on, machine will be ready for processing within 10 minutes.

Also leave open the valve(s) in cold water supply line to heat exchanger.

To save time, turn other switches on before exposing film.

CLEARING A FILM JAM

Sheet Film

1. Don't turn off power.
2. Remove crossover ahead of pile-up.
3. Remove films at this point to avoid further pile-up. Put films in tray of water to prevent sticking.
4. Clear the film jam. Turn off circulation if a rack is removed.
5. Feed the removed films into rack nearest point of jamming, to complete cycle.
6. Determine cause of jam and correct it.

Roll Film

1. Shut off the power.
2. Cut film at feed table.
3. Clear film from racks.

MAINTENANCE

For daily maintenance, see "Operation."

CLEANING

Don't drip solutions into an adjacent tank when removing a rack. Reinstall racks slowly, or solution will overflow. Don't interchange developer and fixer racks.

WEEKLY

1. Remove crossovers and wipe with damp sponge or cloth. Use a nonmetallic pad for stubborn dirt and chemicals.
2. Clean the stainless feed rollers and be sure they turn freely.
3. Remove solution racks. Check tanks for foreign matter. Rinse racks with running water, and clean off any chemical deposits and dirt. Use a nonmetallic scrub pad for stubborn deposits.
4. Check spring tension on racks. Be sure roller bearings are free. Operate each rack manually to check for binding. Check for loose set screws. Lay rack on a flat surface, and be sure it is square. Use fiber or nylon brush to clean gear teeth. Replace worn gears and springs. Reinstall racks and crossovers.
5. Clean dryer rollers with a clean damp cloth.
6. Clean dryer air tubes by removing and agitating vigorously in warm water.
7. Be sure dryer rollers are properly seated.
8. Go over the entire machine and clean it thoroughly.

MISCELLANEOUS

1. Clean developer rack(s) whenever a soil pattern transfers to film. When normal cleaning isn't adequate, use chemical dissolving solutions according to instructions.
2. Change dryer air filters when dirty.
3. Change solution filter cartridge(s) when circulation is impeded (change at least once for every 2000 average-size films processed).
4. Remove and clean screen in bottom of replenisher tanks when solutions are changed. Swirl the screen thru solution to remove trapped air bubbles.
5. When you change solutions, drain tanks and flush thoroughly before refilling.
6. At least once a month, flush replenisher systems with hot water-- not over 150° F (65° C). Give special attention to check valves and flowmeters (remove and disassemble).
7. Clean the solenoid valve periodically (frequency depends on cleanliness of water supply).

LUBRICATION

See manufacturer's Lubrication chart.

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IM 38-520-129
046

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE & SURGERY
X-RAY BRANCH

Automatic Processor

The field of radiography is becoming more and more automated and mechanized to keep pace with new procedures and ever-increasing workloads. Automatic processors have evolved from days of manual processing, through automatic hanger processing to present day hangerless, automatic processors Automatic processors offer the added benefits of better quality control, faster processing, and they are automatic, compact, and much cleaner in operation.

NOTE: Show S 38-520-129-1.

There is much about the automatic processor which is not understood, or is misunderstood. More specifically, many people have never recognized the fact that an automatic processor is composed of systems. Each system performs specific duties and, consequently, causes specific problems, while participating in the overall processing of a radiographic film from the latent image into a diagnostic quality visible image. Every processor has the same systems.

To help you better understand the automatic processor and automatic processing, let us examine together the systems as they are found in all makes and types of processors. To accomplish this, we are going to build a processor, and we are going to use systems engineering. That is to say, we will develop a system to work as a single section within the processor, but one which functions with respect to the other systems also. This is systems engineering.

NOTE: Show S 38-520-129-2.

The basic systems necessary to automatic processors are the chemistry system, the tempering system, the transport system, the circulation/filtration system, the replenishment system, the air/dryer system, and the electrical system. Most of these systems are the same as found in manual processing. For instance, in manual processing the film is transported by hand instead of by an automatic roller system, and films are agitated by hand instead of using an automatic recirculation pump.

Now, let us consider each of the individual systems as we build our processor. The first system is the Chemistry system.

NOTE: Show S 38-520-129-3.

Modern day automatic processor chemistry and film are designed to produce optimal results in an automatic processor. It was because of the special requirements of the processor that chemical companies innovated polyester base, faster processable film emulsions, and the necessary high activity, low temperature chemistry.

NOTE: Show S 38-520-129-4.

The necessary chemical components are the developer, fixer, and wash water. Developer action is to break down the exposed silver bromide crystals to black metallic silver. To keep the processor compact, the provision for a rinse tank or stop bath has been eliminated, and instead, a pre-hardener is added to the developer. This is usually glutaraldehyde, and it is designed to harden the emulsion (a little) before the film enters the fixer. This is the main difference between manual and automatic film processing. The fixer removes the unexposed silver bromide crystals and hardens the film emulsion. Wash water is considered a chemistry because it is necessary for the washing or dilution of the fixer out of the emulsion and is important in hypo retention.

Because the fixer is acid and neutralizes the developer, we must take great care in keeping these chemistries separate; so let us design stainless steel tanks for the chemistry.

NOTE: Show S 38-520-129-5.

At this point our automatic processor looks like a manual tank. We can hook the dryer section on to the end to form the four main compartments of the automatic processor. This also forms the two main sections: the wet section and the dry section.

NOTE: Show S 38-520-129-6.

In this slide we see the tanks of a processor with the developer tank at the top of the picture. This tank is followed by the fixer, then the wash tank. Notice the condition of the tanks and remember the fact that a clean processor produces clean films. These tanks are very dirty, and unless thoroughly cleaned, they will lead to problems and result in unacceptable radiographs.

NOTE: Show S 38-520-129-7.

The tempering system controls the temperature of our chemistries, and since all processing is based on the time/temperature system, we must design a way of controlling the temperature. In general, the higher the temperature, the more active becomes the chemistry. Accurate and consistent temperatures will result in improved quality control.

For the developer we can provide a heating element and a thermostat. A thermometer tells us the temperature of the solution in the processing tank. To keep the developer heating element working at peak efficiency, we can run the developer through a heat exchanger. The heat exchanger consists of a container through which passes a large volume of water, which should be about 5° F. below the desired developer temperature. In this way, heat is exchanged between one solution and the others so that all solutions achieve a stabilized working temperature relative one to the other. To control the wash water we mix hot and cold water with a mixing valve and check the temperature on a thermometer gauge as in this slide.

NOTE: Show S 38-520-129-8.

Notice that between the mixing valve and the thermometer there is a shutoff valve. This is to prolong the useful and accurate life of the mixing valve assembly. To obtain accurate readings, the thermometer is placed directly in the flow path of the tempered water and a pressure release valve is provided. Additional equipment should include filters and a flowmeter.

Now that we have the chemistry system set up and the tempering system designed to regulate chemistry temperatures, let us design a system to automatically move the film through the various compartments.

NOTE: Show S 38-520-129-9.

This system is composed of the transport subsystem and the drive subsystem. However, the entire system includes the following: the feed tray for properly positioning the exposed film; transport of the film through the processing compartment of the wet section into the dry section; and transport through the dry compartment to the catch bin, where the finished visible image radiographs are collected. The actual movement of the film is either in one plane (horizontal or vertical), or it involves making a turn. Whether the film is moved vertically or horizontally, we can use either paired or offset rollers. To make the film go around a turn, whether at the bottom of a main rack or as found in the crossovers, we can use the same principle. This involves a large roller, termed a master (or sun or solar) roller, around which are placed planetary rollers. Because modern film bases are fairly stiff, they need to be directed; so we put in guide shoes which deflect the film around the corner. Remember, there are many varieties of roller systems possible, but they all follow these basic features of moving a film in a plane or around a bend.

With the drawings on these two slides in mind, let us look at our transport system components. This slide shows the entrance roller assembly with one roller that floats up when a film is fed into it from the feed tray. Notice the microswitches which are a part of the replenisher system. The film is moving in a flat position as it comes off the feed tray, and it is necessary to deflect it down into the developer solution. We do this with a very simple entrance crossover consisting of a roller and two guide shoes.

NOTE: Show S 38-520-129-10.

As mentioned above, we can use different types of roller combinations to move the film through the chemistry compartments. Represented here are the racks from four different processors. Each accomplishes the same task of transporting the film through the chemistry. The size of the rack, along with the transport speed of the rollers, determines the processing cycle times. For our processor that we are building, we can use any of these racks. This rack has offset rollers with the center row being the main drive rollers. Notice the lower section of the rack. This is the turnaround assembly. The film comes down to the bottom of the rack along one side, then it is guided around the turn and moves up toward the top of the rack on the opposite side. By laying the rack on its side, we can see the turnaround assembly at the bottom. Notice two of the three guide shoes (one on the top side and one on the bottom of the rack). The bottom guide shoe is between the two planetary rollers. In the center is a master roller. Note that in this turnaround there are two planetary rollers and three guide shoes. This combination works just as well as other racks that have three planetary rollers and two guide shoes. This particular rack assembly is driven by a chain called a ladder chain which drives sprockets on the rollers. Both the chain drive and the vertical shaft drive must be properly tensioned.

NOTE: Show S 38-520-129-11.

After constructing the necessary racks and crossovers, we need to move the whole transport system as one unit. This is the job of the drive subsystem. The basic components are the drive motor, the processor drive shaft, and a series of cog wheels that transfer the energy to the rollers. Notice the drive motor with its drive chain to the processor drive shaft. On the motor drive shaft there is a drive sprocket or gear, and on the processor drive shaft, there is a driven sprocket.

The gears of the roller assembly drive mechanism mesh with the gear of the processor drive shaft to activate the rollers. The weight of the rack is kept off the gears by a support bar. This reduces the load on the motor.

NOTE: Show S 38-520-129-12.

Putting all of the parts of the transport system together, we can see how the transport system moves the exposed latent film from the feed tray through the chemistry section, where it is processed to a visible image film, and finally through the dryer section, where it is deposited in the catch bin. A cutaway view of an actual processor is very similar to this drawing.

NOTE: Show S 38-520-129-13.

Notice the similarity of the crossovers and the turnarounds.

NOTE: Show S 38-520-129-14.

The movement of the rollers does not provide sufficient agitation in the automatic processor; so it is necessary to develop a circulation system to keep the chemistry properly mixed and properly agitated. This includes recirculation of the developer, fixer, and an adequate wash water flow rate. To keep the chemistries clean, we can install filters on the water lines, the chemistry replenisher lines, and a filter on the developer section to remove dirt and by-products of development.

NOTE: Show S 38-520-129-15.

The circulation pumps and the developer filter can be hooked up in this manner, or they can be hooked up in the following manner.

NOTE: Show S 38-520-129-16.

The replenishment system is designed to pump a measured amount of our chemistry, developer, and fixer from separate tanks into the processing tanks. This is necessary because the chemistry changes slightly as each film passes through it during the processing cycle. Fresh, full-strength chemistry is stored in the replenisher tanks, which are equipped with dust covers and a floating lid in the developer tank to reduce exposure to the air which causes oxidation. When the film is fed through the entrance assembly of the transport system, a microswitch is activated, turning the pump on. The replenisher pump pumps a measured amount of replenisher chemistry to the processor tanks. Notice the filters, flow-meters, and the checkpoints for checking the amount the pump puts out.

NOTE: Show S 38-520-129-17.

Here is a typical pump. This is the Gorman-Rupp two-solution metering pump. Notice the color of the tubing. The darker tubing appears hard and very discolored by the developer and should be replaced. A technologist is checking the replenishment rates. This should be done weekly and only when the replenishment tanks are half full.

NOTE: Show S 38-520-129-18.

The basic components of an air/dryer system are a blower to move the air, a heater, and an adequate exhaust system. Notice the large blower and the blower motor. At the very bottom you can see the square opening of the blower with the heating elements just above. The round holes are the ends of the air tubes which direct the moving warm air onto the film.

NOTE: Show S 38-520-129-19 & 20.

Here we see the air tubes in place with their guide fingers and part of the transport roller system. It is not shown, but it is important to have an adequate exhaust system to remove the warm moist air from the processor.

NOTE: Show S 38-520-129-21.

Electricity is the source of power required to operate our processor. Suffice it to say that only a qualified electrician or properly trained person should work on the electrical system. However, because the electrical system powers the other systems, let us take a minute to consider a typical wiring schematic. Notice first that the processor should be connected to a circuit breaker. Next, notice the switches and fuses. Switch number 4 controls the entire air dryer system. One-half of switch number 3 controls the circulation system, while the other half controls the developer heating in the tempering system. Switch number 2 controls the microswitches, which, in turn, control the replenishment system and various accessories. Switch number 1 controls the main drive motor. Each of the various systems is basically wired and controlled separately.

NOTE: Show S 38-520-129-22.

In this slide, notice the switches (in this processor only three switches are used), the fuses, and main terminal strip.

We have now constructed a complete processor based on the individual systems. In your work involving automatic processors, whether it be daily maintenance or in repairing the processor, remember the various systems involved and what they do.

At this point, you should have an awareness of the principle that all processors are alike. What you have learned here is applicable to any make or model of processor since, indeed, all processors are alike. As further proof of this, it should be pointed out that the pictures you have seen of actual processors include the X-Omat Models M-2, M-4, M-4A, M-4B, and M-6, the Pakorol Models X and XM, and the Profexray.

The precautionary measures and proper maintenance for the automatic processor are clearly outlined in Annex B. These should be adhered to if continued optimum results are expected from the automatic processor.

During the last hour we have covered the complete systems and functions of the automatic processor. A thorough understanding of the systems of the automatic processor will enable you, as X-ray specialists, to be more efficient in producing X-rays.

ACADEMY OF HEALTH SCIENCES *LP 38-520-307
MEDICINE AND SURGERY DIVISION 028
X-RAY BRANCH

X-Ray Administration (2 hours)

COURSES PRESENTED TO: 313-91P10, X-Ray Specialist

PLACE: Classroom

REFERENCES: AR 40-2, AR 340-18-9

STUDY ASSIGNMENT: Handouts and Notes

STUDENT UNIFORM AND EQUIPMENT: None

TOOLS, EQUIPMENT, AND MATERIALS: M 38-520-139-1 and 2.

PERSONNEL: One instructor, 91P2H/91P3H/91P4H

INSTRUCTIONAL AIDS: Chalk, chalkboard, eraser; film file envelope, handouts.

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Lecture

I. INTRODUCTION (5 min)

A. Opening Statement: Every type of business must have a workable filing system if it is to run efficiently. You could very well be in a position where you would have to set up a new clinic or take over an established one. Your knowledge of X-ray administration will be the key to an efficient and productive clinic.

B. Objectives

1. Identify an ideal work flow pattern in a Radiology Department.

2. Describe the handling of the SF 519a from origin to file.

3. State the function of the SSAN color coded negative preserver, family member prefix number, retirement color code, and the patient status in the terminal digit file system.

4. State the disposition of exposed X-ray films according to AR 340-19-9, C-14.

C. Class Procedure and Lesson Tie-in: None

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*This lesson plan supersedes LP 38-520-307, 067.

LP 38-520-307
028

II. EXPLANATION (80 min)

A. Work flow Pattern in A Radiology Department

1. Film handling

a. Exposure room

b. Darkroom

NOTE: The advantage of a centrally located darkroom is that it allows an expedient work flow pattern in the clinic by requiring the shortest possible distance between the exposure rooms and the darkroom.

c. Film assembly area

d. File room

e. Reading room

NOTE: Films that are considered and noted on the SF 519a as wet readings, stats, ASAP, and hand carries are given to the patient, ward, or clinic after the films have been interpreted.

2. Model master rotation schedule

NOTF: Show a model master rotation schedule

a. Exposure room

b. Fluoroscopy room

c. File room

NOTE: One area of responsibility of the person working in the file room is to pull the negative preservers (films) for the clinics; i.e., orthopedics, surgical, and internal medicine clinics.

d. Darkroom

e. Film assembly area

f. Portables

g. Receptionist desk

NOTE: It is necessary to schedule certain examinations to facilitate more accurate and speedier service for the patient by assuring proper preparation and assemblance of necessary equipment and personnel.

NOTE: A daily ledger is kept on all examinations handled in the Radiology Department. Information contained in the daily ledger usually forms the basis for activity reports and will vary from clinic to clinic.

NOTE: Length of time spent in each area will vary from clinic to clinic.

QUESTION: Why are X-ray specialists' assignments in a clinic made on a rotating basis?

ANSWER: The specialist will remain proficient in all areas of the clinic and will be assigned to a potential exposure area only half of his/her duty time.

B. SF 519a from Origin to File
  1. Ward or clinic
  2. Receptionist
  3. X-ray specialist
  4. Film assembly area
  5. Reading room
  6. Radiologist office (SF 519a)
    a. Original
    b. Duplicate

QUESTION: Who can sign the SF 519a?

ANSWER: Any Medical Corps officer.

C. Terminal Digit Filing System
  1. Purpose: More efficient method of filing, utilizing the sponsors SSAN as the filing number, not only for himself, but for the family as well.
  2. Filing number (SSAN)
    a. Primary group
    b. Secondary group
    c. Family member prefix group
      (1) Bona fide dependents

(4) Foreign nationals

(3) Civilian emergencies

3. Negative preserver (DA Form 3443 through 3443-9)

NOTE: Refer to handouts and show negative preserver.

a. Use of primary group to determine color of negative preserver

NOTE: Demonstrate black tape over last number of SSAN on negative preserver.

b. Use of secondary group number

(1) Written in blocks at the top of the negative preserver

(2) Designates the order in which the primary group is filed

4. Retirement color code

NOTE: Year film taken determines the color tape placed over block "R."

5. Status color code

a. Military

b. Foreign nationals

c. All others

D. Disposition of Exposed X-Ray Films

1. AR 340-18-9, C-14

2. Installation patient X-ray films

3. Procurement and separation X-ray films

QUESTION: A US Army soldier had an emergency leg X-ray in February 1970. When would his films be withdrawn and salvaged if no additional forms were taken?

ANSWER: 1976, after 1 January.

E. Questions from Students

NOTE: Make assignment: After class, review M 38-520-307-1 and 2 and notes.

III. SUMMARY (5 min)

A. Review of Main Points

1. Work flow pattern
2. Filing number
3. Negative preserver
4. Retirement color code
5. Patient status
6. Disposition of exposed X-ray films

B. Closing Statement: The administration of an X-ray clinic is only as efficient as the persons affiliated with it. When you arrive at your clinic, you must become thoroughly familiar with the routines and methods that are in use because these methods are considered to be the best suited for use in that particular clinic.

ACADEMY OF HEALTH SCIENCES
MEDICINE AND SURGERY DIVISION
X-RAY BRANCH

*IM 38-520-307
028

X-Ray Administration

Every type of business must have a workable filing system if it is to run efficiently. Any of you could very well be in a position where you would have to set up a new clinic or take over an established one. Your knowledge of X-ray administration will be the key to an efficient and productive clinic.

The actual arrangement of an X-ray clinic will be determined by the room space available and the number and type of patients who will be handled in that clinic. The equipment will depend upon the mission of the hospital.

The ideal work flow pattern in a Radiology Clinic for film handling is: the film will move from the exposure room to the darkroom to the film assembly area, to the file room, to the reading room.

The assignment of X-ray specialists in the clinic will be based upon the number of rooms, the work load, the equipment, and the number and grade of the specialists on duty. Outside activities such as mandatory training and CIP must be considered, but the protection of the specialists from overexposure to secondary radiation is a very important factor.

Assignments are usually made on a rotating basis either monthly or weekly. A good example of a rotation schedule would be one week in an exposure room, one week in a fluoroscopy room, one week in the file room, one week in the darkroom, one week in the film assembly area, one week on portables, and one week on the reception desk. This rotation has two benefits: the specialist will remain proficient in all areas of the clinic and will be assigned to a potential area of exposure only one-half of his duty time.

Patients should be scheduled whenever possible for maximum efficiency and utilization of all equipment and personnel. Each clinic will have its own policy in scheduling as well as in film checkout and wet readings. You must learn the SOP followed in your clinic and comply with it.

In some wards and/or clinics a physician, upon examining a patient, will determine that an X-ray examination will aid him in his treatment and/or diagnosis of a particular case, and he will have an X-ray request slip (SF 519a) made out for his patient. This patient will report to the receptionist in the clinic, and the specialist on duty must verify all information to make certain it is correct and determine if the patient has had previous films taken in that particular clinic.

Information from the request slip (SF 519a) will be entered in the daily ledger, a chronological record of all patients as they enter the clinic. The information contained in the daily ledger usually forms the basis for activity reports and will vary from clinic to clinic, but the

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This instructor's manuscript supersedes LP 38-520-307, 067.

usual entries are the terminal digits of the SSAN, patient's name, rank, SSAN, the examination, and the classification or status of the patient. Other information such as the number of films used and the age of the patient may also be entered in the daily ledger.

When the receptionist has processed the request slip (SF 519a), the specialist working in the exposure room will call the patient, make the exposure as per the request, and endorse the request with the number and size of the films used and his initials or identifying number.

The specialist working in the film assembly area will sort all requests separating old and new numbers. Envelopes will be made for all new patients. If the patient had been previously X-rayed in that particular clinic, the SF 519a and the new films are then sent to the file room and the specialist assigned to that area would pull the old jacket and up-date it. The latest films with the SF 519a are then placed on the outside of the jacket.

The assembled films will be taken to the radiologist for his interpretation. He will write or dictate his report, which will be entered in the appropriate space on the SF 519a, and sign the SF 519a in the proper space. The original of the report will be returned to the initiating ward or clinic, and the duplicate copy will be kept on file in the X-ray clinic according to that clinic's SOP.

The filing system, which the Army now uses for the film files, is the terminal digit system covered in AR 40-2, C-14. It is a more efficient method of filing, utilizing the sponsor's SSAN as the filing number not only for himself, but for his family as well. The terminal digit number used to identify the patient's film will be the last four numbers of the SSAN. The terminal digits include a primary group or the last two digits and a secondary group or second last two digits; that is, in the SSAN 38-30-6810, the 6810 is the terminal digits, the 10 is the primary group, and the 68 is the secondary group.

The first two digits placed in front of the SSAN, the family member prefix identify the patient as follows: sponsor - 20; spouse - 30; oldest child - 01; next oldest child - 02; third oldest child - 03; mother - 40; father - 45; mother-in-law - 50; father-in-law - 55; other bona fide dependents - 60, 61, 62. Foreign nationals will be given a prefix of - 00. Emergency patients not eligible for medical care are also given the prefix - 00. For example, PFC Ernie Jones, SSAN 390-22-3734, would be identified as 20 39022 37 34; his wife's number would be 30 39022 37 34; his third oldest child's number would be 03 39022 37 34 for the identification of X-ray film files

To obtain positive control over misfiling, negative preservers (DA Form 3443 through 3443-9) are color coded and blocked. The color of the negative preserver indicates the primary group of numbers; for example, orange represents primary groups 00 to 09; light green represents 10 through 19 and blocking out one of the preprinted digits along the border (0 through 9), it will represent the last digit of the SSAN, such as "0" in the SSAN 328-30-6810

The secondary group of numbers is written in the blocks at the top of the negative preserver, and it designates the order in which the primary group is filed; the remaining figures are filed numerically.

Predesignated tape affixed on the block indicated by an "R" will indicate the retirement date of those X-ray films. For example, a film is taken in 1974 and color coded for tentative retirement by placing a strip of red tape over the block printed "R." The red tape indicates the tentative retirement date of 1 January 1980. Other tapes used for the retirement color code are dark blue (81), dark green (82), yellow (83), silver or white (84), black (85), and orange (86). This sequence will be repeated every seven years.

By affixing a predesignated color tape to the block indicated "S" will indicate the status of the patient. For example, red indicates active duty military personnel, silver indicates foreign nationals, and black indicates all others.

The handling of exposed X-ray films is governed by AR 340-18-9, C-14. This AR discusses basically two types of films - installation patient X-ray films and procurement and separation X-ray films. Installation X-ray films are kept for at least five calendar years, and the tape which was placed over block "R" on the negative preserver serves as a guide for salvage. For example, all films taken in 1974 must be kept throughout the complete calendar years of 75, 76, 77, 78, and 79; after 1 January 1980, all negative preservers marked with red tape will be pulled from the files and salvaged if no new films have been added. If a new set of films is added to the negative preserver, the new tape would be placed on the negative preserver and the effective date would change. If additional films were taken in 1976, the red tape would be covered with dark green tape. This negative preserver would then be kept through 1981 with the new salvage date after 1 January 1982.

The procurement and separation X-ray films are sent to the National Personnel Records Center (civilian), St Louis, Missouri, in SSAN sequence, daily, weekly, or monthly, depending on the rate of accumulation. In addition to the types of films previously discussed, there are other categories which are covered in AR 340-18-9, C-14.

The administration of an X-ray clinic is only as efficient as the persons affiliated with it. When you arrive at your clinic, you must become thoroughly familiar with the routines and methods that are in use because these methods are considered to be the best suited for use in that particular clinic.

ACADEMY OF HEALTH SCIENCES *LP 38-520-308
MEDICINE AND SURGERY DIVISION 018
X-RAY BRANCH

Stereoscopy (1 hour)

COURSES PRESENTED TO: 313-91P10, X-Ray Specialist

PLACE: Classroom

REFERENCES: TM 8-280

STUDY ASSIGNMENT: After class, study TM 8-280, pages 13-23 to 13-28

STUDENT UNIFORM AND EQUIPMENT: TM 8-280

TOOLS, EQUIPMENT, AND MATERIALS: None

PERSONNEL: One instructor, 91P2H/91P3H/91P4H

INSTRUCTIONAL AIDS: Chalkboard, chalk, and eraser; pointer; one each set of stereo radiographs of skull, chest, shoulder

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Lecture

I. INTRODUCTION (3 min)

A. Opening Statement: Have you ever seen a 3-D movie or looked at pictures through a stereoscope? Do you know that the same thing can be done with X-rays simply by shifting the X-ray tube and taking two slightly different views? This procedure is called stereoscopy.

B. Objectives

1. Determine the purpose of stereoscopic examinations.
2. Determine the ratios and rules for tube angulation, shift directions, and correct identification placement.
3. Compute the total tube shift for a given stereoscopic exam.
4. Identify the accessory devices used in stereoscopic examinations.

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*This lesson plan supersedes LP 38-520-117, 046.

5. Identify the five steps used in determining right-eye, left-eye films for correct stereo viewing.

II. EXPLANATION (40 min)

A. Purpose: The purpose of stereoscopy is to allow the use of the third dimension (depth) in radiographic films.

   1. Spatial relationship
   2. Perspective
   3. Examples of use
      a. Tuberculosis
      b. Hairline fractures
      c. Accessory sinus
      d. Dislocations
      e. Foreign bodies

B. Ratios

   1. Interpupillary distance vs viewing distance
      a. Interpupillary distance is normally 2.5 inches
      b. Viewing distance is normally 25 inches
      c. Ratio 1:10
   2. Tube shift distance vs focal film distance
      a. 1/10 of the FFD will be the total amount of the tube shift
      b. Ratio 1:10

C. Computation of Total Tube Shift

   1. Formula for tube shift:

$$\frac{\text{Interpupillary distance}}{\text{Viewing distance}} = \frac{\text{TSD}}{\text{FFD}}$$

   2. Example
      a. Given: FFD = 40 in
         Viewing distance = 25 in, interpupillary distance = 2.5 in

b. Find TSD

c. $\frac{2.5}{25} = \frac{X}{40}$

$25X = 100$
$X = 4$ in = TSD

QUESTION: What would be the total tube shift for a PA chest with a 72-inch FFD?

ANSWER: 7.2 inches or 10% of the FFD.

D. Rules

1. Tube angulation. The prescribed tube angulation, with respect to the film plane, remains constant, and the tube displacement made at right angles to the direction in which the CR is angled

2. Tube shift direction

   a. For optimum stereopsis, the tube shift should be at right angles to the dominating lines to the part being examined

   b. Chest, vertebral column, pelvis, or joint surfaces, the tube shift should be up and down the part

   c. PA or AP skull, the tube shift is parallel with the vertical plane

   d. Long bones, the tube shift is across the part

3. Correct identification and placement

   a. Legend "STEREO"

   b. Lead arrow "←"

   c. Correct "R" or "L" to indicate the direction of the tube shift

   d. Place all markers and identification out of the part being examined

   e. The lead markers are placed on top of the table for bucky examinations

E. Accessory Devices

1. Cassette changer

2. Bucky
3. Film tunnel

QUESTION: When doing a bucky stereoscopic examination, where is the film identification placed?

ANSWER: On the tabletop.

F. Radiographic Procedure

1. Position patient
2. Position film
3. Tube shift
4. First exposure
5. Tube shift (total amount of tube shift required for this shift)
6. Change film
7. Second exposure

G. Radiographs in Stereoscope - Five Steps for Correct Viewing

1. Superimpose the film images, holding the two films in such a manner so that the radiographic images will have the same relationship to the viewers' eyes that the anatomical part of the patient had with the X-ray tube.

2. With the edges of the films even, note the relationship of one radiographic image to the other. This way, one can determine whether there was a vertical or a transverse tube shift to the patient. If the film's images are to the left and right of each other, the tube shift was transverse. If the images are top to bottom of each other, the tube shift was vertical.

3. When the films are placed one on top of the other with the edges of the films even, that film with the image to the right will be the film placed on the right viewer and the film with the image to the left will be placed on the left viewer.

4. If you found the tube shift to the patient was vertical, the films must be rotated 90 degrees (keeping the tops and bottoms of the films either both to the left or to the right). If there was a transverse shift to the tube in relation to the patient, then no rotation of the films is needed.

5. To compensate for the mirror image when using the mirror-type stereoscope, rotate the films 180 degrees in the horizontal plane.

NOTE: If a prism-type stereoscope is used, the films are NOT rotated.

H. Questions from Students

NOTE: Study Assignment: Read TM 8-280, pp 13-23 to 13-18.

III. SUMMARY (7 min)

A. Review of Main Points

1. Ratios
2. Procedures
3. Viewing
4. Purpose

B. Closing Statement: You have been given the information on stereoscopic procedures. When performing these procedures in the clinic, make sure that your equipment is in operating order before positioning your patient for the exposure. This will eliminate unnecessary radiation to the patient. Study your stereo mechanism collectively on each type machine used in your clinic so that you will understand the operation before exposing patients. This is a must in all X-ray clinics.

ACADEMY OF HEALTH SCIENCES *IM 38-520-308
MEDICINE AND SURGERY DIVISION 018
X-RAY BRANCH

Stereoscopy (1 hour)

Have you ever seen a 3-D movie or looked at pictures through a stereoscope? Do you know that the same thing can be done with X-rays simply by shifting the X-ray tube and taking two slightly different views? This is called stereoscopy.

The purpose of stereoscopy is to obtain the impression of three dimensions in radiographic studies; that is, to also obtain the impression of depth instead of only width and length as on routine radiographs. This procedure is employed to enable the examiner to "see around" obscuring structures which are superimposed on the area of interest on the routine radiograph.

Stereoscopy is a two-view, two-film method of radiography, obtaining solidity of an image by perception of the third dimension, depth.

Normally, depth perception results from a complex intersensory conditioning to visual stimulation. In humans with normal eyes, that is, eyes in their true perspective and in correct spatial relationship, each eye receives a slightly different view of an object. The optic nerves transmit these separate images to the optical thalmus where they are fused into three dimensional images.

The prime objective of all medical radiography is to reveal, for diagnostic evaluation, those structures normally hidden from view. The ordinary single radiograph reveals a given structure in two dimensions: length and width. The information yielded by this method does not permit the best conception of depth, nor does it reveal the relationship of the underlying structures. To secure a more realistic perception of the third dimension, depth, another method is used, namely stereoscopy.

Stereoscopy is particularly indicated when examining anatomical regions of the body that contain complex structures or are of considerable depth. It is often difficult to demonstrate these parts of the anatomy satisfactorily, even with views taken at right angles to each other. This is especially true of the thoracic cage, the skull, the vertebral column, the hip, and the shoulder girdle. The use of stereoscopic radiography is also valuable in gaining a perspective of such conditions as accessory sinuses, hairline fractures, tuberculosis, dislocations, and foreign bodies. The use of stereoscopy gives a better perspective to these conditions by making these structures appear to the examiner to be suspended with respect to their spatial relationship to the surrounding areas so that the definite points of interest are accurately located.

In order to obtain the best perspective of the three dimensions (height, width, and depth), it is necessary that the ratio relationship between the interpupillary spacing and the distance at which the radiographic image is

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*This instructor's manuscript supersedes IM 38-520-117, 046.

1474

viewed be similar to the ratio relationship between the distance of the tube shift (that is, spacing between the two positions of the focal spot) and the focal film distance. These relationships must be as similar triangles. The average spacing between the pupils of the eyes of an audit is 2.5 inches. The average viewing distance is 25 inches. With such a condition, there is a ratio of 1 to 10. For such viewing, the shifting of the focal spot should also have a 1 to 10 ratio to the focal film distance.

The following formula can be used to obtain the desired tube shift:

$$\frac{\text{Interpupillary distance}}{\text{Viewing distance}} = \frac{\text{Tube shift distance}}{\text{Focal film distance}}$$

For example, assuming that the following factors are true, find the tube shift distance:

Focal film distance = 40 inches
Viewing distance = 25 inches
Interpupillary distance = 2.5 inches
Tube shift distance = X

$$\frac{2.5}{25} = \frac{X}{40}$$

$$25X = 100$$

$$X = 4 \text{ inches (tube shift distance)}$$

The prescribed tube angulation, with respect to the film plane, remains constant and the tube displacement made at right angles to the direction in which the CR is angled.

When making stereographic exposures, the direction of the tube shift should be at right angles to that of the predominating lines of the part being examined; when the long bones are the subject, the tube moves at right angles to the long axis; in the case of the chest, where the ribs are the dominant lines, the movement of the tube shift is along the line of the vertebra; while, if the vertebral column is being examined, the tube shift is across the trunk. In certain exceptions, such as the skull, the direction depends upon the precise area being investigated. Usually, when the skull is under consideration, the general rule is when a PA or AP view of the skull is taken, the tube shift is parallel with the vertical plane. For a lateral projection of the skull, the direction of the tube shift will either be up and down or crosswise, depending on the preference of the responsible viewer. Since the purpose of stereography is to secure an impression of perspective, the two exposure points should be chosen with that in mind.

There is a difference of opinion regarding the best means for identifying stereoscopic radiographs. For instance, lead letter markers may be used to indicate "right" and "left" tube shifts or a lead arrow marker that casts an image may be used to designate direction of tube shift. Regardless of the method used, the identification data is the same as for ordinary radiographs. The lengend "STEREO," made up of lead letters and used in conjunction with conventional film identification markers, aids in assembling the films and in establishing the correct position for their viewing.

Where the marker is placed is another important factor. If possible, all of the identification data should be placed on the tabletop or attached to the top of the film tunnel or on the "face" of the cassette changer, rather than directly on the cassette or film holder. This provided an orientation point which remains in exactly the same site during both exposures, and is especially applicable in cases where the flash-card system of identification is used.

Radiographs for stereoradiography may be taken with any of the three accessory devices. The three devices are: (1) the bucky tray, (2) a stereoscopic cassette changer (commonly seen in an X-ray clinic as an upright chest changer), or (3) cassette-changing tunnel.

The steps involved in producing a stereoradiographic examination are, except for a few modifications, the same as for any type of radiographic examination. The first step is to position the patient in accordance with the routine positioning standards for that clinic. After the patient has been positioned, the film should be positioned for that examination. The tube is then moved in the proper direction required for the area being examined, one-half the total tube shift. The first exposure is then made and the tube is then moved the opposite direction of the first tube shift, the total amount of the calculated distance required. The film is changed to prevent a double exposure. At this time the second exposure is made and the patient is instructed to relax. Remember that it is important that the patient is not to move between the first and second exposure.

Many pitfalls await the X-ray specialist who varies from the established method utilized in viewing stereoradiographs. "True" stereo provides a depth perception of anatomical relations. There are only two acceptable methods by which "true" stereo can be viewed. Any deviation from these two methods will produce "pseudo" or false stereoscopy. Pseudo stereoscopy shows the radiologist a flat or shallow depth image which frequently leads to incorrect reports with respect to pathology. Correction of pseudostereoscopy is extremely time consuming and causes great eye fatigue to the physician, especially when hundreds of films are being "read" daily. The following methods can be relied upon as the proper five steps on setting up stereo films for proper left-eye, right-eye viewing:

1. Superimpose the film images, holding the two films in such a manner so that the radiographic images will have the same relationship to the viewer's eyes that the anatomical part of the patient had with the X-ray tube.
2. With the edges of the film even, note the relationship of one radiographic image to the other. This way, one can determine

whether there was a vertical or a transverse tube shift to the patient. If the films' images are to be left and right of each other, the tube shift was transverse. If the images are top to bottom of each other, the tube shift was vertical.

3. When the films are placed one on top of the other with the edges of the films even, that film with the image to the right will be the film placed on the right viewer, and the film with the image to the left will be placed on the left viewer.

4. If you found the tube shift to the patient was vertical, the films must be rotated 90 degrees (keeping the tops and bottoms of the films either both to the left or to the right). If there was a transverse shift of the tube in relation to the patient, then no rotation of the films is needed.

5. To compensate for the mirror image when using the mirror type stereoscope, rotate the films 180 degrees in the horizontal plane. NOTE: If a prism-type stereoscope is used, the films are NOT rotated.

REMEMBER, the films of a stereo pair are positioned properly only if there is easy depth perception and the projected image reestablishes the relations of the part of the patient with respect to the tube.

You have been given the information on stereoscopy. When performing these procedures in the clinic, make sure your equipment is in operating order before positioning your patient for exposure. This will eliminate unnecessary radiation to patients. Study your stereo mechanism collectively on each type machine used so you will understand the operation before exposing patients. This is a must in any X-ray clinic.

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE & SURGERY
X-RAY BRANCH

*LP 38-520-122
056

Vasography (3 hour)

COURSES PRESENTED TO: Radiographic Procedures (Basic), 313-91P20

PLACE: Classroom

REFERENCES: TM 8-280

STUDY ASSIGNMENT: After Class Review: TM 8-280, pp 12-25 to 12-30 and pp 14-36 to 14-54

STUDENT UNIFORM AND EQUIPMENT: TM 8-280

TOOLS, EQUIPMENT, AND MATERIALS: M 38-520-122-1 issued at beginning of class.

PERSONNEL: One instructor from the X-ray Branch (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Radiographs of the vascular system; chalkboard, chalk, eraser, pointer; radiographic illuminators

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Lecture, demonstration

I. INTRODUCTION (5 min)

A. Opening Statement: What is vasography? Try to picture a large city map with the streets and highways crossing and intersecting with one another. Now picture the vascular system in the same perspective. We all know when there is a traffic jam in the large cities, the traffic in a particular area comes to a standstill. The arteries, veins, and capillaries function like the highways for they supply nutrition to the body organs. Since these organs are dependent on nutrition from the blood, blockage could impair their function or cause it to cease. As an X-ray specialist you will be required to know the procedures and methods in locating these blockages of the vascular system in radiography.

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*This lesson plan supersedes LP 38-520-122, 010.

1478

LP 38-520-122
056

B. Objectives

1. Classify and define the main divisions of vasography.
2. List the purposes for vasography and lymphangiography.
3. Identify the contrast media used in vasography and lymphangiography.
4. State the points of injection for each examination in vasography and lymphangiography.

C. Class Procedure and Lesson Tie-in

None

II. EXPLANATION (120 min)

A. Definition: A radiographic examination of the blood vascular system made visible by the introduction of a sterile aqueous solution.

B. Purpose.

1. Aneurysms
2. Tumors, clots
3. Coarctation - stenosis
4. Sclerosis
5. Heart and pulmonary circulation
6. Level of amputation

C. Main Divisions

1. Arteriography
    a. Definition: A radiographic examination of the artery.
    b. Point of injection: Proximal to area of interest.
2. Venography
    a. Definition: A radiographic examination of the veins.

1479

b. Point of injection

(1) Direct method - distal to area of interest

(2) Indirect method - inject into artery - exposure made during return flow.

3. Capillariography

a. Definition: A radiographic examination of the capillaries

D. Contrast Media

1. Hypaque 35% - small vessels

2. Hypaque 70% or 90% - large, fast flowing vessels.

E. Basic Procedure

1. Scheduled exam

2. Sensitivety test

3. Position patient

4. Preparation of site

5. Local anesthetic

6. Cut down

7. Tourniquet if required

8. Contrast media introduced

9. Radiographic procedure

F. Types of Examinations

1. Upper extremities (Arteriography)

Point of injection - brachial artery

NOTE: Show film of vasography of upper extremity.

QUESTION: What is the point of injection for arteriography of the upper extremity?

ANSWER: Brachial artery

2. Lower Extremities (Arteriography)

Point of injection - femoral artery

NOTE: Show films of vasography of lower extremities.

QUESTION: What is the point of injection for arteriography of the lower extremity?

ANSWER: Femoral artery

3. Head (cerebral Arteriography) or (Carotid Angiography)

Point of injection - carotid artery

NOTE: Explain the method of obtaining a venogram of the skull.

NOTE: Show both arterial and venous phase of vasography of the skull.

QUESTION: What is the common point of injection for cerebral arteriograms and venograms?

ANSWER: Carotid artery.

4. Heart and Pulmonary (Angiocardiography)

Point of injection - antecubital vein

NOTE: Show Angiocardiograms.

QUESTION: What is the point of injection for angiocardiogram?

ANSWER: Antecubital vein.

5. Other Examinations

a. Venograms

b. Selective angiography - catheter

c. Cardiac catheterization

G. Special Equipment

1. Rapid film changers

a. Sanchez - Perez (multiple 11x14 cassettes)

b. R1L 400 (multiple 14 x 51 cassettes)

c. Elema Schonander (14 x 14 single film)

d. Franklin F200 (roll type film)

e. Bi-plane unit

2. Pressure injectors

H. Lymphangiography

1. Definition: radiographic examination of the lymphatic nodes and ducts.

2. Purpose - cancer

3. Contrast media

Ethiodol - iodized poppy see oil - 6 to 12cc

4. Point of injection - dorsal portion of each foot

I. Questions From Students

NOTE: Study Assignment: TM 8-280, pp 12-25 to 12-30 and 14-36 to 14-54.

III. SUMMARY (10 min)

A. Review of Main Points

1. Definition

2. Purpose

3. Main Divisions

4. Contrast Media

5. Basic Procedure

6. Types of Examinations

7. Special Equipment

8. Lymphangiography

1482

LP 38-520-122
056

B. Closing Statement: The exact procedure followed in the vasographic examinations will vary from one X-ray clinic to another; however, the basic theory will remain the same. Therefore, it is essential that a thorough understanding of this theory be mastered by the prospective X-ray specialist.

1481

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE & SURGERY
X-RAY BRANCH

*IM 38-520-122
056

Vasography

What is vasography? Try to picture a large city map with the streets and highways crossing and intersecting with one another. Now, picture the vascular system in the same perspective. We all know when there is a traffic jam in the large cities, the traffic in a particular area comes to a standstill. The arteries, veins, and capillaries function like highways for they supply nutrition to the body organs. Since these organs are dependent on nutrition from the blood, blockage could impair their function or cause it to cease. As an X-ray specialist, you will be required to know the procedures and methods in locating these blockages of the vascular system in radiography.

Most major hospitals in the Army perform vasographic examinations. It is essential that the X-ray specialist have a working knowledge of vasographic procedures in order to assist the radiologist in completing these examinations.

Vasography is the general term applied to the roentgenographic investigation and study of the blood channels in selected portions of the circulatory system after injection of a radiopaque contrast medium to render them visible.

Some of the pathology that may be visualized through vasography are aneurysms, sclerosis, tumors, blood clots, heart chambers, pulmonary circulation, levels of amputation, and it may assist in deciding upon operative measures.

There are three basic divisions of vasography: Arteriography, venography, and capillariography. For all practical purposes, only the arteries and the veins will be considered. Therefore, we list the following:

"Arteriography" is the term applied to the roentgenographic examination of the arteries during or following the injection of a radiopaque contrast medium. The point of injection of the media may vary, however, the point of injection must be proximal to the area of suspected pathology. This is done to allow the blood stream to carry the contrast media toward the suspected area of pathology.

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*This instructor's manuscript supersedes IM 38-520-122, 010.

"Venography" is the term applied to the roentgenographic examination of the veins during the injection of a contrast medium. Venography may be done in one of two ways. In one method, the contrast medium is injected directly into the lumen of the veins and roentgenograms are exposed at the instant a given portion of the venous system is filled with the contrast medium. This method is termed "direct venography."

In the second method, termed "indirect venography," the contrast medium is introduced into a selected portion of the arterial system and roentgenography of the analogously related venous system is accomplished at the time the contrast medium is passing through the veins on its return flow. The roentgenographic visualization of the cebral venous channels is a specific example of indirect venography. The point of injection of the contrast media must be below the site of suspected pathology to allow the blood flow to carry the media to the site of the pathology.

Arteriography. After ascertaining whether the right or the left extremity is to be examined, the X-ray specialist will adjust the patient to a supine position on the X-ray table, with the arm abducted and supinated.

A 14 x 17-inch cassette is placed beneath the outstretched and supinated arm, and the roentgen tube is centered over the site of interest. In addition to the regular identification data, number markers are used to indicate the sequence of exposures.

A sphygmomanometer cuff is wrapped around the most proximal portion of the arm under examination.

The site of injection is rendered aseptic and from 1 to 2 cc of 0.5 percent procaine solution is injected into the skin and subcutaneous tissues over the brachial artery. The contrast medium to be used is warmed to body temperature and is placed in a syringe. A 19-gauge needle is used to make the puncture of the brachial artery.

The X-ray specialist selects the roentgenographic technique factors and adjusts the controls of the X-ray unit. Normally, routine factors for the part will suffice, but the exposure time should be as short as possible. With everything in readiness, the X-ray specialist assumes the "ready" position so that the exposures can be made without delay when the examiner gives the signal to make the exposure.

The sphymomanometer cuff is quickly inflated above the systolic blood pressure by the examiner or an assistant, and then the contrast solution is injected into the brachial artery. Immediately after completion of the injection, the needle is quickly withdrawm and the first exposure is made when the examiner gives the signal. The patient should have been instructed beforehand to remain absolutely motionless at the time the exposure is being made.

The examiner will then deflate the sphygmomanometer cuff below the diastolic blood pressure for a period of approximately 2 to 4 seconds and then execute rapid reinflation of the cuff to the previous systolic blood pressure level. During this time, the X-ray specialist must execute a rapid exchange of cassettes and be prepared to make the second exposure when the examiner gives the signal. Additional exposures may be made by repeating this procedure.

When specific or localized areas of the extremities are the object of clinical interest, then pronationof the part, rather than supination, may be indicated, and lateral views may also be included in the study.

Since the examiner usually works in close proximity to the field of exposure, proper safeguards must be employed for his protection. For example, a leaded screen, positioned nearby the X-ray table, will provide a relatively safe shelter for the examiner during the times the films are being exposed. Cones should be used. A technical difficulty that is frequently encountered in the accomplishment of this procedure is the mistiming of the exact instant of exposure. For this reason, it is well to remember that perfectly timed teamwork is vitally important to the success of the examination.

Venography. As soon as the patient arrives at the clinic, the X-ray specialist will determine from the examiner the site of injection and the particular portion of the extremity to be examined. The patient is then placed in the supine position of the X-ray table, with the arm to be examined abducted and supinated.

If the examination is localized to any specified region lying distal to the proximal third of the arm, a 14 x 17-inch cassette is placed beneath the extremity and adjusted so the greater portion of the cassette surface is mostly proximal in relation to the injection site.

If the object of the examination is to demonstrate the venous channels situated in the upper portion of the arm, axillary, shoulder girdle, or upper thoracic regions, then the patient should be positioned in relation to the midline of the X-ray table in such a way that the desired coverage will be obtained. In this case, Bucky technique is used. Identification markers are preferably placed on the table top to facilitate rapid changing of cassettes.

The site of the injection is rendered aseptic and local anesthetic is administered. The injection needle is then inserted into a vein selected by the examiner. The rate of injection and amount of contrast medium to be used is determined by the examiner.

1486

When the X-ray specialist is given the signal by the examiner, he will make the first exposure. The exact time at which this exposure is made may vary from the instant the injection is completed to 5 or more seconds afterward. Additional exposures or views are made according to the directions of the examiner.

In some cases, the patient may be instructed to suspend respiration while the exposure is being made; in other cases, he may be allowed to breathe normally.

Technique factors are usually the same as those normally used for routine roentgenography of the bony structures which lie in the same regional aspect as the blood channels under examination.

Arteriography. If the examination is concerned with any part lying distal to the knee, nongrid technique is normally employed. Bucky technique is indicated for any area above the knee.

The patient is positioned on the X-ray table with the lower extremity under consideration adjusted to the anteroposterior position. A 14 x 17-inch cassette is placed beneath the extremity and centered to the region to be examined.

After the administration of the local anesthesia, the examiner inserts the injection needle into the lumen of the common femoral artery, just distal to the inguinal ligament. The examiner then gives the "ready" signal and rapidly injects the contrast medium. At the same time, the examiner (or assistant) applies manual or mechanical pressure to the femoral artery proximal to the site of the injection. At the instant the injection is completed, the examiner signals the X-ray specialist to make the first exposure.

Immediately following the first exposure, the specialist will rapidly exchange cassettes. Pressure on the femoral artery is removed and the examiner signals the specialist to make the second exposure. Additional views are made per instructions of the examiner.

Venography. For venography in the horizontal position, the patient is positioned on the X-ray table in the supine position. The lower extremity to be studied is aligned to the midline of the table.

For venography in the erect or the semierect position, the patient stands on a footrest which has been fastened to the X-ray table. The X-ray table is tilted approximately 65 to 80 degrees from the horizontal. The footrest should be adjusted to an elevation adequate to permit the examiner to have easy access to the working site. An immobilization band should be placed over the patient's chest, just beneath the armpits, to provide support. The part to be examined is aligned to the midline of the table, a 14 x 17-inch cassette is placed in the Potter-Bucky film tray, and the X-ray tube is positioned for a horizontal projection.

After the examiner determines the site to be injected, the site is then rendered aseptic and local anesthesia is administered. The injection may be accomplished by the percutaneous method, or by "cutting down" and surgically exposing a selected vein at a given site. The site of injection may be in either the ankle region or the dorsum of the foot.

After the injection needle has been inserted into the vein, it is secured in position with adhesive tape. The contrast medium is then injected at a rate varying from 1 to 5 cc per second. The examiner signals the X-ray specialist to indicate the instant at which the first exposure is to be made. This signal may be given from 5 seconds to more than 120 seconds after completion of the injection.

Head (cerebral arteriography) (cerebral angiography). The patient is placed in a supine position and centered to the midline of the table. Scout films of the skull are per instruction of the examiner for wet-reading.

A sterile layout consisting of the instruments and materials required for cerebral arteriography is prepared for use. The side of the neck selected for the site of injection is made aseptic, and the chest is draped with sterile towels.

If the injection is to be carried out by the percutaneous method, the examiner palpates the carotid artery at the neck to determine the best site for puncture. He selects the site where the pulsation is the strongest and then introduces a local anesthesia by injecting a procaine solution into the subcutaneous tissues and deep fascia. After waiting several minutes for the procaine solution to take effect, the examiner inserts the needle into the lumen of the artery and then connects the needle to an adapter in the injection system.

With all participants alerted, the examiner instructs his assistant to apply pressure to the carotid artery. The examiner gives the "ready" signal to the X-ray specialist and injects the contrast solution at a rate of approximately 10 cc per second. As the final one or two cc's leaves the syringe, the examiner signals "shoot" and the X-ray specialist makes the first exposure.

In the absence of rapid-sequence serializing exposure apparatus, the X-ray specialist will execute a rapid exchange of cassettes and expose the second film as quickly as possible. The pressure opposite the side of the site injection is released. The second exposure, when executed 3 to 5 seconds after injection, will represent the radiopaque medium passing through the venous phase of circulation. This film is actually a type of cerebral venogram.

Heart (angiocardiography.) The primary purpose of this examination is to study the chambers of the heart and the immediate major vessels surrounding the heart. The pulmonary circulation may also be examined, as it is necessary for the contrast medium to pass through this circulation to go from the left to the right side of the heart.

A tourniquet is applied around the upper region of the patient's arm. A suitable injection needle is inserted into the antecubital vein, either percutaneously or after surgical exposure of the vein. Following this, the tournique is removed. In some instances, a special type of catheter is used to introduce the contrast medium. The catheter may be inserted in the external jugular vein and advanced to the heart; or it may be introduced in the greater saphenous vein and advanced through the femoral and illiac veins to the vena cava.

In the case of an unanesthetized and cooperative patient, the upright position is generally used. The horizontal position may be employed for the following reasons: The preference of the examiner, the type of recording apparatus used, the condition and age of the patient (e.g., the patient may be anesthetized if uncooperative, unpredictably syncopal, or may be a very young child).

When everything is in complete readiness; all participants alerted, the X-ray unit turned on, technique factors selected, and the standby button depressed for proper rotating anode acceleration; the examiner begins injection of the contrast medium. At the exact instant the injection is begun, the X-ray specialist starts to time the process with a stopwatch. At the exact instant the predetermined time interval elapses, the X-ray specialist makes his first exposure. A second exposure is made at the next predetermined time interval. Additional exposures or views are made as directed by the examiner.

Approxiamte time intervals of opacification of the heart, after beginning of the injection, are given in Annex A of this manuscript.

Bi-Plane Unit. The purpose of the Bi-Plane Unit is simultaneous views at right angles. Right angle viewing allows the examiner to obtain the perspective of the third dimension.

This unit takes a series of exposures at high speeds, and may utilize roll film or sheet film to accomplish this series of radiographs.

The rapid-type changers now used in most radiology departments are: (1) Elema Bi-Plane (roll-type film changer), (2) Franklin Bi-Plane (roll-type film changer), (3) Fairchild Unit (single plane roll-typed), (4) Schonander single and Double Plane Unit (sheet-film changer), (5) Sanchez- Perez Single Plane Unit, which employs multiple wafer-thin cassettes.

The exact procedure followed in the vasographic examinations will vary from one X-ray clinic to another; however, the basic theory will remain the same, necessitating a thorough understanding of this theory by the prospective X-ray specialist.

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE & SURGERY
X-RAY BRANCH

*LP 38-520-121
125

Body-Section Radiography (2 hours)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCE: TM 8=280

STUDY ASSIGNMENT: After class Review TM 8-280, pp 13-60 thru 13-64.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280

TOOLS, EQUIPMENT, AND MATERIALS: None

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Chalkboard, chalk; appropriate radiographs, viewboxes; 500-MA radiographic unit with body-section attachment.

TROOP REQUIREMENTS: None

TYPE OF INSTRUCTION: Lecture (1st hour); demonstration (2d hour)

FIRST HOUR

I. INTRODUCTION (5 min)

A. Opening Statement: When one views a typical radiograph, for example, a PA view of the chest, it immediately becomes apparent that what is actually demonstrated in any given film area is not single structure, but rather a composite of many structures superimposed one upon the other. In certain instances, some of these structures will obscure the site of prime interest. By means of body-section technique the objectionable structure can, to a great extent, be blurred out and therefore demonstrate the structure of prime interest more clearly. During this unit of instruction, you will learn the general procedures employed in body-section radiography so you will be able to apply the skills learned in this course.

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*This lesson plan supersedes LP 38-520-121, 032

B. Objectives

1. List the purposes of body-section radiography.
2. State the effect the fulcrum height has on the depth of cut.
3. State how amplitude and FFD effect the thickness of the cut.
4. After practice, properly assemble and disassemble the body-section apparatus.

C. Class Procedure and Lesson Tie-in

None.

II. EXPLANATION (35 min)

A. Definition: A generic term encompassing several methods, and is the demonstration on film of a specific layer (cut) with the exclusion of overlying and underlying structures.

B. Purpose

1. Determination of pathology level
2. Examination of predetermined layer
3. Help demonstrate hairline fractures

C. Principles of Body-Section Radiography

1. Effect of tube and film movement
    a. In relation to the part
        (1) Single layer - relationship of layer with plane of film
        (2) Points above and below single layer
2. Apparatus

NOTE: Explain the use of a fulcrum in conjunction with rod connecting tube and film carriage, and the resultant movement. Use chalkboard.

3. Fulcrum point - determines the layer of the body that is demonstrated.

D. Tube Movement Systems

1. Rectilinear movement - blur in a straight direction

2. Pluridirectional (polytomography) produces controlled blur

   a. Circular

   b. Elliptical

   c. Hypocycloidal (maximum movement - maximum blurring)

NOTE: Put radiographs on viewboxes demonstrating blurring caused by movement of tube and film.

E. Methods of Body Sectioning

1. Laminagraphy

   a. Special adaptations

      (1) Planigraphy (most commonly used)

      (2) Vertigraphy

2. Tomography

3. Stratography

NOTE: This method will not project a plane.

4. Other various methods

   a. Pantomography

   b. Axial transverse laminagraphy

F. Machine Adjustments

1. Fulcrum

2. Section (layer) thickness

   a. FFD - measured vertically

      (1) Increase (amplitude constant) thicker

      (2) Decrease (amplitude constant) thinner

1493

b. Amplitude - distance of movement (sweep) of tube; controls thickness

(1) Increase (FFD measured vertically - constant) Thinner.

(2) Decrease (FFD measured vertically - constant) Thicker

3. Rate of tube travel

4. Exposure time

Formula: $S = \frac{A}{R}$ S = time A = amplitude

R = rate of tube travel

5. MAS 50% to 100% increase

QUESTION: What two factors determine the thickness of the layer examined?

ANSWER: FFD and amplitude.

QUESTION: What determines a given level of the layer or cut?

ANSWER: Fulcrum height.

G. General Procedure

1. Positioning of patient
2. Breathing technique
3. ID placement and information
4. Patient protection
5. Simultaneous multilayer body-section radiography - book cassette

F. Questions From Students

NOTE: Make assignment: After class Review TM 8-280, pp 13-60 thru 13-64.

III. SUMMARY (5 min)

A. Review of Main Points

1. Definition
2. Purpose
3. Principles
4. Tube movement systems
5. Methods
6. Machine_adjustments
7. General procedure

B. Closing Statement: Though body-section radiography is not accomplished regularly in most X-ray clinics, occasionally the need for an examination of this type may arise, thus making it important for an X-ray specialist to know how to perform the examination.

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*IM 38-520-121
125

Body-Section Radiography

When one views a typical radiograph, for example, a PA view of the chest, it immediately becomes apparent that what is actually demonstrated in a given film area is not single structure, but rather a composite of many structures superimposed one upon the other. In certain instances, some of these structures will obscure the site of prime interest. By means of body-section technique the objectionable structures can, to a great extent, be blurred out and therefore demonstrate the structure of prime interest more clearly. During this unit of instruction, you will learn the general procedures employed in body-section radiography so you will be able to apply the skills learned in this course.

Body-section radiography is a generic term encompassing several methods and is the demonstration on film of a specific layer (cut) with the exclusion of overlying and underlying layers.

We can use body-section radiography to determine the level of pathology, to examine a predetermined layer, to help demonstrate hairline fractures (especially where complex structures are involved), and for various other purposes.

We are going to discuss the principles of body-section radiography that you will be using as an X-ray specialist.

When making the exposure for the body-section examination, the tube and film move in planes parallel to each other and at any angle to the film surface. To accomplish this, a rod (strap) connects the tube and film carriage. The rod usually pivots on a point which we call the fulcrum, causing the tube and film carriage to move in opposite directions. The CR is directed to the center of the film at all times. As the tube and film move all points will be blurred out except for the points on the place located at the level of the fulcrum; this plane (layer) is parallel with surface of film; the ratio of FFD to focal plane distance remains constant. When a rectilinear (straight line) movement of the tube and film is used, all points above and below the layer demonstrated will be blurred in a straight line direction. When circular, spiral, or sine curve movement of the tube and film is used, all points above and below the layer demonstrated will produce blurs respective to the movement used.

One of the disadvantages of body-section radiography is the necessity for making repeated exposures at various levels of fulcrum height to adequately demonstrate a sizable lesion in a large structure. This entails massive irradiation to the patient, is time-consuming, is conducive to error in the demonstration of those parts which move with respiration, and requires the patient to lie motionless for long periods. These objections have been overcome to a large extent by the development of a method whereby several layers can be simultaneously recorded with one exposure.

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*This instructor's manuscript supersedes IM 38-520-121, 032

Simultaneous multilayer body-section radiography is done by placing several "sandwiches" consisting of films and intensifying screens, in a thick cassette (book cassette) with balsa wood or suitable foam rubber spacers placed between the sandwiches. Equal spacing of these sandwiches will produce radiographs of equally spaced layers in the body, although the dimensions in the body and in the cassette will not be identical. There are various methods to compensate for the absorption of radiation by the sandwiches.

The identification strip and a lead numeral identifying fulcrum height are placed on top of the cassette. Only a layer of the patient's body is demonstrated and thus the ID would be blurred out if placed on the tabletop. In a multisandwich cassette, each screen usually has a code which is reproduced on the film; this code represents the location of the films within the cassette in relation to the top film.

The type of distortion of objects outside the layer visualized is determined by the type of motion used. Circular motion may produce either circular or double image artifacts. Rectilinear motion most effectively blurs out objects lying at right angles to the direction of motion, whereas long objects oriented in the direction of motion produce rodlike artifacts. These facts should be given consideration in positioning the spine, ribs, and long bones during examinations involving rectilinear motion. When shadows of these structures must be eliminated, the long axis of the body or part may be positioned diagonally on the table.

There are various methods used by body-section examinations. We will discuss a few in detail and briefly mention the others.

In laminagraphy, the tube and film move in planes parallel to each other and at any angle to the film surface. While remaining at a constant distance from the tabletop, the film and tube can move in a straight line, in circles, in spirals, or along a sine curve.

As an X-ray specialist, you will most likely use the planigraphy method. In planigraphy, the tube and film move in planes parallel to each other and to the film surface. Planigraphy is a special adaptation of laminagraphy. Because of the back and forth motion of the tube and film in planigraphy, a grid or Bucky can be used to control SR.

In vertigraphy, the tube and film move in planes parallel to each other and perpendicular to the film surface. Vertigraphy is also a special adaptation of laminagraphy.

In tomography the tube and film move in concentric arcs. The film surface maintains its orientation with respect to the plane or layer of the body to be radiographed.

In stratigraphy, the tube and film may move around a stationary body while having no relative motion to each other; or, the tube and film may remain stationary while the body rotates. This method will not project a plane. The angle of rotation determines the width of the strip as well as the thickness.

Some of the other various methods are axial transverse laminagraphy, variable magnification, and pantomography.

As an X-ray specialist, you will mostly be using the planigraphy method of body-section radiography. We will discuss the machine adjustments you will have to make when doing planigraphy.

The layer of the body demonstrated will be at the same height above the tabletop as the fulcrum. The fulcrum level can be adjusted to various heights above the tabletop. Determination of the proper fulcrum level is usually made from routine radiographs although the single-film triangulation method of foreign body localization can also be used for making precise fulcrum-level determinations.

The thickness of the layer demonstrated is determined mainly by the FFD and the amplitude. (Amplitude is expressed as the distance the tube travels during the exposure, measured in inches.)

A variety of FFD can be used with most equipment. This FFD is measured vertically. Keeping the amplitude constant, an increase in FFD will result in a thicker layer being demonstrated; a decrease in FFD will result in a thinner layer being demonstrated.

The amplitude of tube motion can be varied. Keeping the FFD (measured vertically) constant, an increase in amplitude will result in a thinner layer being demonstrated; a decrease in amplitude will result in a thicker layer being demonstrated.

The rate of tube travel, expressed in inches per second, may be varied within the limits of the type of equipment used.

The exposure time is equal to the amplitude divided by the rate of tube travel. The formula $S = A/R$ can be used, where S is the exposure time measured in seconds, A is the amplitude measures in inches, and R is the rate of tube travel measured in inches per second. For example, with an amplitude of 20 inches and a rate of 10 inches per second, the correct exposure time would be 2 seconds.

In body-section radiography, the MAS is controlled by using an appropriate MA setting correlated with the exposure time. While the MAS required varies with the particular body part under consideration, a factor of 1.5 to 2 times the normal MAS for the given projection is recommended.

IM 38-520-121
125

Though body-section radiography is not accomplished regularly in most X-ray clinics, occasionally the need for an examination of this type may arise, thus making it important for an X-ray specialist to know how to perform the examination.

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE & SURGERY
X-RAY BRANCH

*LP 38-520-123
036

Prenatal and Pelvimetry (1 hour)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES: TM 8-280, pp 13-1 thru 13-5

STUDY ASSIGNMENT: After class Review TM 8-280, pp 13-1 thru 13-5.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Prenatal radiographs; radiographic illuminators; and Colcher-Sussman equipment

TROOP REQUIREMENTS: None

TYPE OF INSTRUCTION: Demonstration

I. INTRODUCTION (5 min)

A. Opening Statement: Such physical factors as unnatural fetal position, incompatibility of fetal and pelvic sizes, could present serious obstetrical problems. Comprehensive evaluation of such complications, which almost invariably includes accurate radiographic examination of the fetus and pelvis, is required to determine the optimum course of action. The radiographic techniques employed for such examinations range from arteriographic studies to standard abdominal radiography. Since determination of fetal position (fetography), and measurement of the fetal head and pelvis (pelvimetry) are most frequently requested, discussion, here will be confined to these examinations.

B. Objectives

1. Define the purpose of fetography, and pelvimetry.
2. Describe the preparation of a patient for fetographic and pelvimetric examinations.
3. State the type of pelvimetric procedure used most often in Army clinics.

This lesson plan supersedes LP 38-520-123, 070.

4. Describe the difference between fetography and pelvimetry.

5. After practice, properly position and produce clinically acceptable pelvimetric and fetographic radiographs.

II. EXPLANATION (35 min)

A. Fetography

1. Definition - demonstration of the fetus in uterus

2. Purpose - the presence, size (or age), condition, number, and position of the fetus

3. Preparation of patient - patient void

4. Positions

a. AP

b. Lateral

NOTE: Show and explain AP and lateral fetographs.

NOTE: Some clinics may prefer PA instead of AP as part of the routine.

c. PA variation - central ray 27 degrees cephalic

QUESTION: Why do we do fetography?

ANSWER: To determine size, age, and position of the fetus.

B. Pelvimetry

1. Definition - Radiographic examination of the maternal pelvis

2. Purpose - Diametric, or volumetric comparison between the fetus and the maternal pelvis

3. Colcher-Sussman method

a. Radiographs of Colcher-Sussman method

NOTE: Place the films on the illuminator for class observation.

b. Measurements taken from each view

c. Equipment - Radiopaque metal ruler on adjustable stand

d. Positions

(1) AP

(2) Lateral

NOTE: Wait for cessation of fetal movement.

QUESTION: What considerations other than breathing must be taken into consideration before the exposure?

ANSWER: Cessation of fetal movement.

QUESTION: How do we determine when fetal movement has stopped?

ANSWER: We do not; the patient tells us.

C. Questions From Students

NOTE: Make assignment: After class study TM 8-280, pp 13-1 thru 13-5.

III. SUMMARY (5 min)

A. Review of Main Points

1. Definition and purpose of fetography
2. Positions for fetography
3. Colcher-Sussman method for pelvimetry

B. Closing Statement: Remember that these examinations are dealing with an unborn fetus, extreme care must be taken in selecting technical factors to produce a clinical acceptable radiograph the first time without error.

1502

ACADEMY OF HEALTH SCIENCES, US ARMY
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X-RAY BRANCH

*IM 38-520-123
036

Prenatal and Pelvimetry

Such physical factors as unnatural fetal position, incompatibility of fetal and pelvic sizes, could present serious obstetrical problems. Comprehensive evaluation of such complications, which almost invariably includes accurate radiographic examination of the fetus and pelvis, is required to determine the optimum course of action. The radiographic techniques employed for such examinations range from arteriographic studies to standard abdominal radiography. Since determination of fetal position (fetography), and measurement of the fetal head and pelvis (pelvimetry) are most frequently requested, discussion, here will be confined to these examinations.

Fetography. Preparation of patient. While it is desirable to clear the lower bowel of gas and fecal material before examination, it is not done without the explicit instruction of the responsible medical authority. In every case, the patient should be instructed to void just before the examination, because a full or partially filled urinary bladder may prevent obtaining a satisfactory radiograph. Have the patient dressed in a suitable cotton gown.

Equipment. When available, a generator and tube of high capacity should be employed in order to obtain maximum film quality.

The exposure time should be as short as possible to keep within the safe limits of the tube and generator.

It is imperative that an efficient grid or Potter-Bucky diaphragm be used and to cone down to the most practical limits.

An X-ray unit capable of upright radiography with a Bucky gird is preferred.

All equipment should be in complete readiness before the patient is positioned. Obstetrical patients in the advanced stages of pregnancy are often very uncomfortable when placed in certain positions.

PA projection. The patient is placed in the prone position with the thorax and pelvis elevated by means of pillows or folded blankets placed under the chest and thighs, in order to avoid undue pressure on the patient's abdomen. Midline of patient to center of table with

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*This instructor's manuscript supersedes IM 38-520-123, 070.

head resting on chin, avoiding rotation of the head. A 14 x 17 cassette is centered in the Bucky tray lengthwise with its lower border in line with the gluteal fold. Central ray to center and perpendicular to plane surface of film. Respiration suspended at the end of exhalation. In every case of prenatal radiography, instruct the patient beforehand to inform the specialist by prearranged signal, when there is a cessation of fetal movement. Exposure should be accomplished with the control of respiration at the quiescent stage of the fetus.

Lateral projection. The view may be made with the patient in either the upright or recumbent position. The patient is placed in the true lateral position with the overally center of the abdomen to the midline of the radiographic table. A 14 x 17 cassette is centered in the Bucky tray lengthwise. The center of the film to the level of the apex of the abdomen. Central ray to center and perpendicular to plane surface of film. An IV stand placed approximately at arm's length in front of the patient will serve as a support for the patient's arms during exposure for the lateral upright projection. Pillows or suitable sandbags placed between the patient's knees and legs will aid in obtaining and maintaining a true lateral view with the patient in recumbent position.

AP projection. The specialist should ascertain what the customary or preferred procedure is in a particular clinic or service - whether to make PA and lateral or AP and lateral views. The patient is in a supine position with median plane to center of radiographic table. Center of film to level of the apex of abdominal curve. Central ray to center and perpendicular to plane surface of film. Place pillow, folded blankets, or suitable sandbags under patient's knees to relieve possible strain or discomfort.

PA projection (variation). This projection is often indicated or preferred in cases of early pregnancy (approximately from the 13th or 14th week of pregnancy). The patient is in a prone position with median plane to midline of radiographic table. Place sandbags under the patient's ankles to relieve discomfort to toes. Central ray angled 27 degrees cephalad and directed to the region of the anus and terminating at center of film. A 10 x 12 size is usually adequate. Respiration is suspended at end of exhalation.

Roentgen pelvimetry. General. Since there are numerous methods of procedures for doing roentgen pelvimetry, and individual variations of these methods, it is not in the scope of this lecture to present all of them in detail. One method which embodies the basic fundamentals will be briefly outline. This will provide you a means to establish a practical insight into the basic roentgenographic mechanics involved.

1504

IM 38-520-123
036

The roentgen pelvimetry is a radiographic examination of the maternal pelvis. This examination is done for diametric or a volumetric comparison between the fetus and the maternal pelvis.

Colcher-Sussman method. General. Two views are required for this method, the AP and lateral views.

Equipment. This consists of a radiopaque metal ruler with pinhole perforations spaced at 1cm. intervals and mounted on an adjustable stand.

Procedure - AP projection. Have the patient dressed in a suitable cotton gown. The patient is in a supine position with the median plane of patient to the midline of radiographic table. The knees are flexed with sandbags placed at the patient's feet. When necessary, place towel so as not to expose patient. Separate the thighs enough to allow for placement of pelvimetric ruler. The ruler is placed transversely and centered to gluteal fold at the level of the ischial tuberosities. To determine this level, measure distance from symphisis pubis to tabletop and subtract 10 cm., adjusting the pelvimetric rule to this level. Center of cassette to a point 1 ½ inches cephalad to the symphisis pubis. Central ray to center and perpendicular to plane surface of the film. Expose the film when the patient suspends respiration at end of exhalation.

Lateral projection. Place the patient in the lateral recumbent position with the midaxillary plane of the body to the midline of the radiographic table. Extend the patient's thighs, and use sandbags to secure immobilization. Place folded sheets or towels under the lower thorax in such a way so that the long axis of the spine is parallel with the tabletop. Place the pelvimetric ruler at the level of the patient's median plane so that it lies within the gluteal fold and against the sacrum. Center cassette at the level of the most prominent point of the greater trochanter. Central ray to center and perpendicular to plane surface of film. Make the exposure when the patient suspends respiration at end of exhalation.

Remember that these exams are dealing with an unborn fetus, extreme care must be taken in selecting technical factors to produce a clinically acceptable radiograph the first time without error.

1505

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DIVISION OF MEDICINE & SURGERY
X-RAY BRANCH

*LP 38-520-118
056

Examination of the Urinary System (3 hours)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES:

TM 8-280, pp 14-20 thru 14-30

STUDY ASSIGNMENT: After class study TM 8-280, pp 14-20 thru 14-30

STUDENT UNIFORM AND EQUIPMENT: TM 8-280

TOOLS, EQUIPMENT AND MATERIALS: None

PERSONNEL: One instructor from X-Ray Branch (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Chalkboard, chalk, eraser, and pointer; radiographic illuminator; roentgenograms; one set films for following exams IVP, retrograde, cystograms, urethrogram, and uterosalpingogram (additional films optional)

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Lecture (3 hours)

FIRST AND SECOND HOURS

I. INTRODUCTION (5 min)

A. Opening Statement: An automobile engine has as one of its parts an oil filter. The water we drink from city water sources has been filtered. Our blood, circulating through our bodies, must also be constantly filtered to remove impurities. We are fortunate, also, in that should one kidney fail, we have another to continue the function. The Urology Service includes many various radiographic procedures as part of their diagnostic testing of the patient. During this unit of instruction, you will learn the general procedures employed in commonly used urographic tests so you will be able to apply the skills learned in this course.

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*This lesson plan supersedes LP 38-520-118, 070

1506

LP 38-520-118
056

B. Objectives

1. List the basic urographic examinations.

2. List the contrast media used for basic urographic examinations.

3. Properly schedule and instruct patient on the proper preparations for the basic urographic examination.

4. Identify radiographs of the basic urographic examinations.

5. Ability to recognize the Emergency equipment and the need for one.

6. After practice, the ability to competently assist the medical officer in performing urographic examinations.

C. Class Procedure and Lesson Tie-in

None.

II. EXPLANATION (125 min)

A. Urography

1. Definition: Radiographic study of the functional and structural anatomy of the urinary systems, after they have been rendered radiopaque with contrast media.

2. Purposes

a. Tumorous masses

b. Stones or calculi

c. Deviation from the normal anatomical relationship of the organs.

d. Impairment of the normal excretory process

B. Anatomy

NOTE: General review to reinforce previous detailed instruction in this area.

1. Kidneys
    a. Position in the body
    b. Functions
2. Ureters
    a. Position
    b. Functions
3. Urinary bladder
    a. Position
        (1) Male
        (2) Female
    b. Function - primary reservoir for the storage of urine.
4. Urethra
    a. Position
        (1) Male
        (2) Female
    b. Function
        (1) Male - Passage of urine and spermatozoa
        (2) Female - Passage of urine

QUESTION: What organs and/or regions are studied in urographic procedures?

ANSWER: Kidneys, ureters, urinary bladder.

NOTE: Accurate medical history of the patient and explaining the procedure in simple terms makes a patient easier to work with which might help prevent reactions.

C. Types of Examinations

1. Intravenous Pyelograms

a. Definition - radiographic examination of the kidneys, ureters, and bladder, with the contrast medium being introduced intravenously.

NOTE: This study is done primarily to determine the functional condition of the kidneys.

b. Patient preparation

(1) Scheduled

(2) Diet restriction - NPO 12 hours prior

c. Radiographic room set-up

(1) Emergency equipment

(2) Contrast medium

(a) Hypaque

(b) Renografin

(3) Radiographic or cystoscopic table - tiltable top

(4) Bucky

(5) Compression devices

(6) Shoulder and footrest

d. Radiographic examination

(1) Patient should void

(2) Scout film - 14 x 17 KUB

(3) Routine - with minute markers (5,10,15, & Post Void)

NOTE: 5 minute film will demonstrate the kidney pelves.

NOTE: A TRENDELENBERG position with compression. Reason - URINE STASIS

(4) Variation: Hypertensive individual (1,2,3,4,5,10,15 and Post Void)

NOTE: Instructor will show radiographs of an IVP.

QUESTION: The IVP is what type of examination or study?

ANSWER: Functional study or examination.

QUESTION: Why is the Trendelenberg position and a compression band used in an IVP examination?

ANSWER: For the purpose of urine stasis.

2. Retrograde Pyelograms

    a. Definition - radiographic examination of the kidneys and ureters, and urinary bladder, with the contrast medium being introduced by way of a cystoscope and catheters.

NOTE: This is a direct structural study.

    b. Patient preparation

        (1) Scheduled

        (2) Diet restriction - none

NOTE: Force fluids to dilate the kidneys and ureters.

    c. Radiographic room set-up

        (1) Emergency equipment

        (2) Contrast medium - Hypaque

        (3) Radiographic or cystoscopic table

    d. Radiographic examination

        (1) Patient should void

        (2) Scout film - 14 x 17 KUB

        (3) Routine - as directed by attending physician

NOTE: PSP Test (Phenolsulphonepthalein) This is done before intro of Hypaque, to see how long after IM or IV it takes for the dye to pass thru the system and drip thru the ureters into the bladder.

1510

NOTE: Retrograde pyelograms are done in surgery or special Urology room. A cystoscope and catheters are needed.

NOTE: Instructor will show radiographs of a retrograde pyelogram.

QUESTION: What instrument is used in connection with retrograde pyelograms?

ANSWER: Cystoscope

3. Cystograms

    a. Definition - radiographic examination of the bladder with the contrast medium being introduced by way of a catheter direct - retrograde.

    b. Patient preparation

        (1) Scheduled

        (2) Diet restriction - none

    c. Radiographic room set-up

        (1) Emergency equipment

        (2) Contrast medium - Sodium iodide solution

            (a) 150cc Hypaque

            (b) 150cc sterile aqueous solution

NOTE: Bladder holds approximately 200-300cc

    d. Radiographic examination

        (1) Patient should void

        (2) Scout film

        (3) Routine - as directed by attending physician

NOTE: Instructor will show radiographs of a cystogram.

QUESTION: Cystography is a radiographic examination of:

ANSWER: Urinary bladder.

4. Urethrograms

a. Definition - radiographic examination of the urethra using a contrast medium. This is both a functional and structural study.

b. Patient preparation

(1) Scheduled

(2) Diet restriction - none

c. Radiographic room set-up

Contrast medium - sodium iodized solution

d. Radiographic examination

NOTE: Routine - as directed by attending physician. Sometimes a voiding urethrogram is done.

NOTE: Instructor will show a radiograph of a urethrogram.

NOTE: Urethrography is a study of the urinary system using a sodium-iodide solution, introduced retrograde to demonstrate the urethra.

D. Urogenital System

1. Definition: Radiographic and fluoroscopic examination of the female reproductive system.

2. Purpose: To demonstrate specified structures of the female reproductive system.

3. HSG Examination - Hysterosalpingogram or Uterosalpingography

a. Patient preparation

NOTE: Scheduled 7-8 days after menstural cycle.

(1) Scheduled

(2) Diet restriction - none

b. Radiographic room set-up

(1) Equipment furnished by OB, GYN

(2) Contrast media

(a) Salpix

(b) Lipiodol

c. Radiographic/fluoroscopic examination

NOTE: This routine varies, according to the attending physician.

NOTE: For the above examination, the system involved is the reproductive; organ under study is the oviducts and uterus; contrast medium preferred is Salpix; and introduced retrograde.

NOTE: Instructor will show a radiograph of a Hysterosalpingogram.

E. Questions from Students

NOTE: Make assignment, study TM 8-280, pp 14-20 thru 14-30

III. SUMMARY (5 min)

A. Review of Main Points

1. IVP

2. Retrograde pyelography

3. Cystography

4. Urethrography

5. Hysterosalpingography

B. Closing Statement: Urographic examinations are done on a routine basis in Army hospitals and clinics. You must not only possess the skills to perform these examinations, you must constantly observe the patient for signs of abnormal reactions and have empathy for the patient. Remember, if it were not for patients we, as X-ray Specialist, would not have a job.

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X-RAY BRANCH

IM 38-520-118
056

Examination of the Urinary System (Urography)

An automobile engine has as one of its parts an oil filter. The water we drink from city water sources has been filtered. Our blood, circulating through our bodies, must also be constantly filtered to remove impurities. We are fortunate also in that should one kidney fail, we have another to continue the function. The Urology Service includes may various radiographic procedures as part of their diagnostic testing of the patient. During this unit of instruction you will learn the general procedures employed in commonly used urographic tests so you will be able to apply the skills learned in this course.

For this period of instruction you must understand that the word "urography" is inclusive of the entire urinary system. Therefore, it includes the study of all the organs that compose it. However, for practical purposes, the specific organs are examined separately. For this reason, urography is further divided into four separate examinations: intravenous pyelography, retrograde pyelography, cystography, and urethrography. One element that is common to all four examinations is that a sodium iodide solution is generally used as the contrast medium

Urography is a radiographic study of the functional and structural anatomy of the urinary system.

The purpose of urography is: (1) The detection of tumorous masses within the structures of the system; (2) for the interpretation of urinary calculi or stones; (3) for the visualization of any deviation from the normal anatomical relationship of the organs of the urinary system, i,e., "floating" kidney, kinking of the ureters, etc.; and (4) to determine any impairment of the normal excretory process of the urinary system.

Before any discussion of the procedure, let us review some of the anatomy and physiology of the urinary system. This will include the location of separate organs and their relationship to anatomical landmarks. These are of utmost importance when positioning the patient for urography.

The kidneys, being the primary organ in the system, will be discussed first. This organ (of which there are two) is located in the upper posterior part of the abdominal cavity, one on either side of the vertebral colume behind the peritoneum. The upper extremity or "pole" is located approximately on the level of the 12th thoracic vertebra

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*This instructor's manuscript supersedes IM 38-520-118, 070

1514

and the lower extremity or "pole" is located at the level of the 3d lumbar vertebra. Due to the displacement by the liver, the right kidney is approximately one-half inch lower than the left. Since the kidneys are not fixed or attached to the abdominal wall, they will drop approximately 1½ inches from the supine to the erect position. This drop is important in radiographic procedures to insure that the organ is localized on the film correctly. Each kidney is approximately 11 cm. in length, 5.5 cm. in width, and 3.5 cm. in thickness.

The function of the kidney is to filter blood in order to remove the toxic byproducts of metabolism. It removes urea, excess sugars, and salts by filtration. The kidneys further help maintain the delicate chemical balance in the body. This chemical balance is a must to insure good health. The glomeruli and tubules perform different functions in the production of urine. The glomeruli is the primary filtering plant, while the tubules transform this filtrate into urine. Approximately 1,000 to 1,800 cc. of urine per 24 hours are produced in the normal healthy adult.

Does anyone have a question as to the function or location of the kidneys?

If there are no questions, we will now discuss the next major structure in the urinary tract, the ureters. These are two tube-like structures that have their upper extremity or portion continuous with the renal pelvis. They are musculomembranous tubes 10 to 12 inches long and 4 to 5 mm. in diameter. The walls of each consist of an inner mucus membrane, then a layer of muscle tissue, and an outer fibrous sheath. They extend from the pelvis of the kidney downward, one on either side of the vertebral column, behind the peritoneum, to the pelvic cavity, then curve downward, forward, and inward and are attached on the lower end to the posterior portion of the bladder.

The urinary bladder is a primary reservoir for the storage of urine. The bladder is a musculomembranous sack located posterior to the pubis and anterior to the rectum in the anterior portion of the pelvic cavity. In females, the bladder is located posterior to the pubis and anterior to the uterus. When the bladder is empty it is recessed into the pelvic cavity. When it is full or distended it rises above the symphysis pubis. Its primary function is to store urine. When sufficient quantity has collected, a nerve impulse relaxes the internal sphincter muscle and allows urine to flow to the external orifice.

This passage from the bladder to the meatus is called the urethra. In the male the urethra is an integral part of the reproductive system. In the female it is independent of the reproductive system. The male urethra is approximately 8 inches long and 1/4 inch in diameter. It is composed of three parts: the prostatic, the membranous, and the cavernous portions. The female urethra is approximately 1½ inches long and ½ inch in diameter. The urethra begins at the bladder and ends at the external orifice. The function of the urethra in females is the passage of urine only; in males it is the passage of spermatozoa as well as for the passage of urine.

There is, in any examination using a contrast medium, a certain amount of danger. I will give you some general rules to help prevent reactions (put these in your notes). 1. The first rule is to get an accurate history of the patient. If he has heart trouble, high blood pressure, or a tightening in the chest, notify the radiologist so he may be informed and will be able to make a decision concerning techniques, etc. Check to see if the patient is allergic to drugs, serums, or food. Again, notify the radiologist if his answer is yes. 2. The second rule is to inform the patient of the procedure, and explain in simple terms so that he may understand. An informed patient is easier to work with than one who is uninformed and afraid. 3. Thirdly, observe the patient; by this we mean to note his physical condition. If the patient shows signs of hives, sweating, pallor, dyspnea, severe vomiting, restlessness, or a rapid pulse, you should note this and immediately bring it to the attention of the radiologist. Supplying the necessary equipment is the specialist's responsibility. A list of these supplies can be found on pages 741 and 742, TM 8-280, March 1967. You should review this list of items and have a knowledge of its content. Lastly, if a patient does go into shock, turn off your machine and stand by to assist the radiologist as needed.

We will now concern ourselves with each of the four divisions of urography separately.

First, intravenous pyelography. This is a radiographic examination of the kidneys, ureters, and bladder, with the contrast medium being introduced intravenously. The IVP is generally the procedure of choice, since it is easier to do and requires little or no operative risk for the patient. It should be emphasized at this time that the IVP is a functional examination. (Put that in your notes.) When doing this examination, there are certain items of equipment that must be present. They are: (1) a high capacity tube and generator; (2) radiographic or cystoscopic table equipped with a tiltable top; and (3) a potter Bucky diaphragm; (4) compression devices, a compression band, and balsa wood blocks. The table must be equiped with a shoulder and footrest. It is essential that all equipment be readied prior to the scheduled time of the examination.

1516

IM 38-520-118
056

The patient should be scheduled at least 24 hours in advance. All fluids and solids are to be restricted.

As you know, the colon overlies the area under consideration and must be free of gas and feces. This is accomplished by witholding food and drink from the patient and giving him a cathartic on the evening prior to the examination. The use of drugs is dependent on the dictates of the radiologist.

Our clinical procedure is as follows:

1. The patient is placed supine on the table and is given an iodine sensitivity test.

2. With the table in horizontal position, a KUB is taken as a scout film. This is developed immediately and given to the radiologist for wet reading. It allows the specialist to make any adjustments in his technique and position. The radiologist can determine how well the bowel is cleansed and to note any outstanding pathology or abnormalities.

3. A vein in the area of the elbow is selected for injection of approximately 20 to 30 cc. of the contrast medium during a 3- to 6-minute interval. While the injection is being accomplished, the patient is cautioned not to swallow. This helps alleviate nausea that may be associated with the injection.

4. For the purpose of urine stasis, either a compression band or placing the patient in Trendelenberg position may be utilized. If a compression band is used, it is usually placed over the ureters. The compression band may be applied either prior, during, or immediately following the injection of the contrast medium, depending on the instruction of the radiologist.

5. From the time of completion of the injection, specific films will be taken at exact time intervals, utilizing 14 by 17 cassettes for all exposures.

Five-minute film. With the patient remaining in either the Trendelenberg position or with the compression band attached, the first exposure is made. This will primarily show the pelves of the kidney. Position the film for a regular KUB.

Fifteen-minute film. Patient remains in supine position, the compression band is released, and an exposure is made. This is primarily for the ureters.

Thirty-minute film. The Trendelenberg position is maintained or a compression-free view is made as the third exposure. This film is usually used for analysis of the degree of free passage from the ureters to the bladder.

Upright film. The patient is placed in a Fowler's position (35 to 45 degrees) and an exposure is amde. This is primarily for the urinary bladder. Remember, you must increase the S factor by one-third for this exposure.

Are there any questions concerning the IVP examination? Remember, it is a functional study. If there are no questions, we will consider the structural studies of the urinary system. One of these is the retrograde pyelogram.

The retrograde pyelogram is defined as a structural study of the urinary system utilizing a contrast medium for the purpose of visualization.

Retrograde pyelography differs from the IVP in three ways: (1) it is a structural examination, (2) fluids are encouraged. The patient is instructed to drink as much fluid as he can tolerate; and (3) the method of introduction of the contrast medium differs. Catheters are inserted through the cystoscope into the ureters in order to enable the dye to be directly introduced into the lumen of the ureters, rather than indirectly through the bloodstream.

The equipment for this examination is essentially the same as for IVP's. You must have a high-speed generator and a tiltable top. A cystoscopic table is preferred; however, a radiographic table can be utilized.

The patient is placed in the supine position on the center of the table. The patient is prepped and the urologist or radiologist introduces a cystoscope through which the catheters will be introduced. These catheters are inserted into the ureters, extending all the way to the pelves of the kidney. A syringe is then attached to the catheter and a contrast medium is introduced.

No pattern is followed for the radiographic procedures; simply follow the instructions of the physician. Therefore, the specialist must be alert to all situations to avoid repeating any examination of this magnitude.

As has been mentioned, retrograde pyelography examination is a structural test. However, there is an associated function test that is used in order to examine that portion of the kidney from the bloodstream to the minor calcyces which are the limits of the retrograde examination.

This functional examination is called the phenolsulfonphthalein (PSP) test. It is administered either intramuscularly or intravenously and eliminated by the kidneys. The function of each kidney is then determined by the time required for the dye substance to appear in the urine trickling through the catheters. This test is done prior to the introduction of the iodine compound. Other associated names for the test are phenol red, time elimination test, or indigocarmine test.

Our next examination is cystography. It is the radiographic examination of the urinary bladder with the use of a contrast media. The preparation for this examination is the same as for retrograde pyelography.

The patient is instructed to empty his bladder as best he can just prior to the examination, and then lie supine on the cystoscopic table. A catheter is then inserted through the urethra into the bladder. The urologist or radiologist verifies that there is no urine remaining in the bladder by allowing drainage through the catheter. After the urologist is satisfied there is no urine remaining, he will then introduce 200 to 300 cc. of sodium iodide solution by injecting it through the catheter. Upon completion of the injection, the catheter is then removed and is clamped and taped to the leg out of the field of exposure. Occasionally, air is used as the contrast medium. When this is done, the examination is referred to as pneumocystography.

Our fourth examination is urethrography. It is the radiographic examination of the urethra with a contrast media and a supplement.

The patient is placed either supine or prone with the body raised in a slight oblique position, which is necessary to radiograph the deep or posterior urethra. A catheter or urethral syringe is introduced into the urethra. In some instances, a supplement (gum acacia) is used in conjunction with the contrast media to cause better adhesion of the media to the lumen of the urethra.

The urologist will notify the specialist when to make exposures. The number and positions taken will depend on the routine of the clinic.

Before we go on to the next examination, are there any questions regarding the urinary system thus far?

The next examination, even though it does not actually belong to the urinary system, is placed here due to the fact of the close proximity to other structures. In the male, as has been noted, the urinary and genital systems are eventually joined and form a combined organ, whereas in the female, these two systems are individual, each separate from the other in function and locations. Further, due to this anatomical location and the similarity of examinations, this examination may be classed under the general title of urography. This examination is known as uterosalpingography or hysterosalpingography. It is a radiographic or fluoroscopic examination of the female reproductive system utilizing a heavy, iodized oil contrast media.

In addition to special gown and draping procedures that will normally be accomplished by the female attendant or doctor, the clinical procedure is: The patient should receive a cathartic the night before and a cleansing enema the next morning prior to the examination. With the patient supine on the table, a vaginal speculum is introduced. A canula is then inserted through the vaginal speculum through the cervical os and into the uterine cavity. An injection of 10 cc. of iodized oil is given, and radiographic exposures are made as directed by the attending gyn doctor or radiologist. Often, the first exposure may be followed by subsequent views in various positions in order to view the entire uterus and fallopian tubes. Because of the delicacy of the structures involved, care must be taken not to injure any tissue by undue pressure when the injection is made. The patient must be protected against unnecessary exposure and embarrassment. A special apparatus may be used prior to injection of the dye to determine the susceptibility of the fallopian tubes. This assists the radiologist in determining the amount of contrast media to use.

Urographic examinations are performed routinely in Army hospitals and clinics. Besides the skill needed to perform these examinations expertly, you have many other responsibilities which include supplies and all necessary information on the request slip. Never attempt to do the examination by yourself. Observe reactions of the patient, and remain aware of the patient's discomfort in all examinations.

ACADEMY OF HEALTH SCIENCES *LP 38-520-313
MEDICINE AND SURGERY DIVISION 018
X-RAY BRANCH

Foreign Body Localization (3 hours)

COURSES PRESENTED TO: 313-91P10, X-Ray Specialist

PLACE: Classroom

REFERENCES: TM 8-280, pages 13-35 through 13-48, and M 38-520-116-1 and 2.

STUDY ASSIGNMENT: After class, review TM 8-280, pages 13-35 through 13-48

STUDENT UNIFORM AND EQUIPMENT: TM 8-280

TOOLS, EQUIPMENT, AND MATERIALS: M 38-520-116-1 and 2 issued at beginning of instruction

PERSONNEL: One instructor, 91P2H/91P3H/91P4H

INSTRUCTIONAL AIDS: Radiographs of foreign body localization, right angle method (PA and LAT); radiographs of single film method; Sweet pedestal tunnel with sliding film holder; Sweet localizer apparatus; Sweet radiographs; Comberg headrest unit; Comberg contact lens; Comberg cassettes; Comberg radiographs; chalkboard and eraser.

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Lecture 1st hour; demonstration 2d, 3d hour

FIRST HOUR

I. INTRODUCTION (5 min)

A. Opening Statement: Regardless of the precautionary measures utilized in safety practices in the Army during peace and war, there are accidents and casualties where foreign bodies must be dealt with throughout your military career as an X-ray specialist. You will perform many foreign body localization examinations.

B. Objectives

1. Define foreign body localization.

2. List conditions concerned with foreign body localization.

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*This lesson plan supersedes LP 38-520-313, 067.

1521

  - a. Presence
  - b. Nature, size, and shape
  - c. Site and manner of entrance
  - d. Reference points, list three

3. List two methods of foreign body localization.

II. EXPLANATION (30 min)

A. Definition: A procedure for examination to determine the presence and position of any object or material foreign to the patient's anatomical makeup.

B. Basic Considerations of Four Inherent Elements

1. Presence
    - a. Motion
    - b. Contrast
    - c. Superimposition
    - d. Artifacts
    - e. Actual or apparent presence of foreign body
        - (1) Structural contours
        - (2) Divergent rays

2. Nature, shape, and size
    - a. Glass
    - b. Wood
    - c. Dirt
    - d. Metal
    - e. Cloth
    - f. Bone

3. Site and manner of entrance

1520

1522

a. Natural or induced

b. Angle of incidence

c. Shifting

(1) Tangential projection of foreign body on peripheral aspect of skull

(2) Angle of incidence. In case of a ballistic or other object introduced at high speed

(3) Shifting of smooth and heavy objects in thoracic and peritoneal cavities

QUESTION: Why would you not depend on divergent rays for localization of foreign bodies?

ANSWER: Foreign body would be distorted in relation to its actual size, shape, and location.

4. Reference points

a. Natural

b. Artificial

c. Topographical

QUESTION: What is an example of a natural foreign body reference point?

ANSWER: Stomach.

QUESTION: What is an example of artificial foreign body reference point?

ANSWER: A marker pointing to suspected foreign body location.

QUESTION: What is an example of a topographical foreign body reference point?

ANSWER: Foreign body located 5 cm superior of right iliac crest and 3 cm lateral of 3d lumbar vertebra.

B. Methods

1. Fluoroscopic

a. Profunda

b. Right angle

2. Radiographic

   a. Right angle

   b. Single film

      (1) Two exposures at 1/2 original mAs

      (2) Locate foreign body - center CR to foreign body

      (3) Make exposure - note FFD on film

      (4) Shift tube 25 percent of FFD

      (5) Make exposure

      (6) Measure distance between the two images

      (7) Apply the formula

$$\frac{\text{Image Shift X FFD}}{\text{Image Shift + Tube Shift}} = \text{Foreign body to film distance}$$

$$\frac{2'' \text{ X } 40}{2 + 10} = \frac{80}{12} = \underline{6.7}''$$

QUESTION: What is the most common and best procedure for foreign body localization?

ANSWER: Right angle projections.

D. Questions from Students

NOTE: After class, review TM 8-280, pages 13-35 through 13-48.

III. SUMMARY (10 min)

A. Review of Main Points

   1. Basic considerations

   2. Methods

B. Closing Statement: You have been given a foundation for radiographic foreign body localization. It is up to you to put this information to good use and become proficient X-ray specialists. You must keep in mind the basic considerations of foreign body localization, with particular emphasis on your reference points because the surgeon, in order to locate, must know the relationship between the foreign body and the anatomical or artificial reference points.

1524

SECOND HOUR

I. INTRODUCTION (5 min)

A. Opening Statement: Because of their sensitivity and delicate nature of structure, the ocular organs require the most precise and careful procedures when dealing with the localization of foreign bodies. To accomplish radiographic foreign body localization in the ocular region, a special type of apparatus and specific modes of technique are used. The most widely used methods in the Health Services Command are the Sweet and Comberg methods. The Sweet's method will now be discussed.

B. Objectives

1. Identify apparatus required for Sweet's foreign localization method.

2. List technical procedure required for the Sweet's foreign body localization method, including positioning and technical factors.

3. Given a radiograph of Sweet's foreign body localization, identify same.

C. Class Procedure and Lesson Tie-in: None

II. EXPLANATION (35 min)

A. Apparatus Required (Sweet Method)

1. Localizer unit

a. Heavy metal base

b. Vertical supporting arm

c. Supporting bracket with setscrew

d. Metal ball and cone (15 mm apart)

e. Spring catch with engaging notch and trigger release for 1 cm movement of ball and cone

f. Sighting notch

2. Headrest unit

a. Special pedestal tunnel

b. Two vertical supporting columns for support of head clamp

c. Pneumatic ring

QUESTION: Does the pedestal tunnel protect half of the film from exposure to radiation?

ANSWER: Yes.

B. Technical Procedure

1. Positioning

a. Lateral recumbent

b. Immobilization of patient

c. Orientation of localizer

d. Central ray part reference

e. Selection of cone coverage (6 inches)

f. Film identification

2. Technical factors

a. Focal film distance - 36 inches

b. Milliampere seconds - 100

c. Kilovolt peaks - 80

d. Make first exposure

e. Shift X-Ray tube 10 inches caudad and tilt tube (CR) through metal ball

f. Move film. Make second exposure

NOTE: Positions will be demonstrated by instructor using student from class as a patient.

C. Radiograph Identification

1. Lateral view of Sweet's foreign body localization

NOTE: Explain and point out foreign body.

2. Oblique lateral view of Sweet's foreign body localization

NOTE: Explain and point out foreign body.

III. SUMMARY (5 min)

A. Review of Main Points

1. Apparatus required

2. Technical procedure and factors

3. Radiograph identification

B. Closing Statement: Intraorbital foreign body localization is an extremely precise procedure. It is imperative that the specialist keep himself adequately informed regarding the essential operational aspects of the procedure because, as the occasion arises in the course of practical X-ray work, the need for this procedure is very great.

THIRD HOUR

I. INTRODUCTION (3 min)

A. Opening Statement: The procedure for performing the Comberg method of intraorbital foreign body localization will now be discussed. As in the case of the preceding method, precision workmanship is of prime importance.

B. Objectives

1. Identify reference points for the Comberg foreign body localization method.

2. Identify the equipment needed to perform the Comberg foreign body localization procedure.

3. List technical procedure for the Comberg foreign body localization procedure to include:

    a. Patient preparation

    b. Anesthetic

    c. Adjustment of lens

    d. Positioning

4. List central ray requirements for the AP and lateral views of the Comberg foreign body localization method.

5. List technical factors required for the Comberg foreign body localization procedure.

6. Given a radiograph of Comberg foreign body localization, identify same.

1527

C. Class Procedure and Lesson Tie-in: None

II. EXPLANATION (40 min)

A. Reference Points

1. Lead markers
    a. Fixed within contact lens
    b. Designation of vertical meridian
    c. Designation of horizontal meridian

2. Contact lens
    a. Fits snugly over eye
    b. Eye anesthetized by 1/2 percent pontocaine hydrochloride

B. Apparatus Required (Headrest Unit)

1. Vertical cassette tunnel

1 2. Horizontal cassette tunnel

C. Determine Technical Procedure

1. Patient preparation
    a. Anesthetize eye
    b. Contact lens adjusted over eye

2. Positioning
    a. Patient lateral recumbent
    b. Patient head adjusted to Water's position
    c. Involved eye aligned opposite lower opening in vertical cassette tunnel
    d. Use adjustable bite bar for immobilization

D. Central Ray

1. Central ray orientation
    a. Horizontal through center of involved eye to vertical film (PA Water's)
    b. Vertical perpendicular through center of eye to center of of film

1528

2. Exposure
    a. Water's
    b. Lateral

QUESTION: What is the position of the central ray for the PA Water's view?

ANSWER: Horizontal perpendicular.

QUESTION: What is the angle and direction of the central ray for the lateral view?

ANSWER: Vertical perpendicular.

E. Technical Factors
1. PA Water's
    a. 36" FFD
    b. 150 mAs
    c. 85 kVp
2. Lateral
    a. 36" FFD
    b. 75 mAs
    c. 85 kVp

NOTE: Show position.

NOTE: Position will be demonstrated by instructor using student from class as a patient.

QUESTION: What is the purpose of the adjustable bite bar?

ANSWER: Immobilization.

NOTE: Show Comberg films.

F. Radiograph Identification
1. PA Water's view of Comberg foreign body localization showing foreign body and bite bar
2. Lateral view of Comberg foreign body localization showing depth of foreign body

1529

NOTE: Make assignment: After class, review TM 8-280, pp 13-35 through 13-49.

III. SUMMARY (2 min)

A. Review of Main Points

1. Reference points
2. Positioning
3. Technique factors

B. Closing Statement: Although the Comberg procedure for intraorbital foreign body localization is relatively easy to execute from a radiographic standpoint, nevertheless, too much emphasis cannot be placed on the need for precise workmanship throughout the entire procedure.

1528

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE & SURGERY
X-RAY BRANCH

SFC WILLIAM HORNIG
*LP 38-520-128
125

Medical Ethics (1 hour)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES: TM 8-280

STUDY ASSIGNMENT: After class, read TM 8-280, pp 9-1 to 9-9.

STUDENT UNIFORM AND EQUIPMENT: None

TOOLS, EQUIPMENT, AND MATERIALS: None

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Chalkboard, chalk, and eraser

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Lecture

I. INTRODUCTION (2 min)

A. Opening Statement: Medical ethics refers to the rules or principles governing the conduct of all persons connected with the practice of medicine. The nature of the work in an X-ray clinic requires that the rules of conduct be very strict. As future X-ray Specialists in the military service, you will be required to apply this knowledge daily in assisting the radiologists. The purpose of knowing and practicing ethical principles is to give you aid in avoiding complications or embarrassment to yourself, your doctor, or the patient.

B. Objectives

1. Describe the principles of good medical ethics.

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*This lesson plan supersedes LP 38-520-128, 090.

2. State the importance of cleanliness in good patient care.

3. List who may act as a chaperone.

4. After practice, display good medical ethics while handling patients.

C. Class Procedure and Lesson Tie-in

None

II. EXPLANATION (40 min)

A. Definition and Purpose

1. Rules and principles

NOTE: Medical ethics is a code which governs one's attitude and moral standards while working with patients.

2. Unauthorized disclosure of information

a. Venture prognosis

b. Elicit information

c. Information by telephone

QUESTION: Who is authorized to instruct a technician to give out information concerning a patient over the telephone?

ANSWER: The radiologist.

B. Military Bearing

1. Addressing patient

NOTE: Address all patients by their proper title (Col.,Pvt., Mr. or Mrs., etc.).

2. Personal hygiene

a. Clean uniform

b. Daily shave

- c. Frequent haircuts
- d. Hands and fingernails

QUESTION: How would you address anyone who came into the X-ray clinic?

ANSWER: By their proper title.

C. Patient Care

1. Patient comfort
   - a. Lifting
   - b. Sitting
   - c. Recumbent
   - d. Palpating patient
2. Chaperonage
   - a. Nurse - female
   - b. Female M.D.
   - c. Female specialist
   - d. Female ward attendent
   - e. Female relative
   - f. Husband
   - g. Female patient

QUESTION: In the process of X-raying a female, who would be chosen first for a chaperon?

ANSWER: A nurse - female.

D. Cleanliness

1. Exposure Room
   - a. X-ray table
   - b. Table or cabinet for supplies

c. Floor

d. Cassette

NOTE: After X-raying each patient, clean the table and all equipment used with a cleaning agent.

2. Accessory equipment

a. Enema tips and bags

b. Catheters

c. X-ray equipment

QUESTION: When preparing a patient for a particular examination which requires palpating, what should the technician do first?

ANSWER: Inform the patient that you must palpate in order to get the correct position.

NOTE: Cite examples of good medical ethics and compare them with poor medical ethics from personal experience.

E. Questions From Students

III. SUMMARY (3 min)

A. Review of Main Points

1. Definition and purpose

2. Military Bearing

3. Patient Care

4. Cleanliness

B. Closing Statement: You are nearing the end of your training. You are well qualified to assist the radiologist. Later, some or perhaps all of you will be licensed in this particular specialty, but qualification or possession of a license, diploma, etc., does not guarantee protection to patients. It cannot, because caring for the sick becomes a moral obligation dependent upon your individual integrity as an X-ray specialist.

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE & SURGERY
X-RAY BRANCH

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*IM 38-520-128
125

Medical Ethics

Medical ethics refers to the rules or principles governing the conduct of all persons connected with the practice of medicine. The nature of the work in and X-ray clinic requires that the rules of conduct be very strict. As future X-ray specialists in the military service, you will be required to apply this knowledge daily in assisting the radiologists. The purpose of knowing and practicing ethical principles is to give you aid in avoiding complications or embarrassment to yourself, your doctor, or the patient.

Working as X-ray specialists, you will be concerned with a number of responsibilities in and about your clinic; however, you must recognize the limitations of those responsibilities. For that reason, in order to maintain good, practical, and desirable results of your work, you are reminded of some basic factors governing ethical conduct.

The specialist may not offer opinions or diagnoses about a patient; nor may he divulge to unauthorized individuals any information whatsoever, unless specifically authorized to do so by the radiologist. The specialist must remember that he shares in the professional knowledge pertaining to a case; he must not violate the position of trust in any way.

The specialist must not discuss the patient's symptoms with him, or question him as to why such examination is necessary or how such an injury occurred. This information has already been given in detail to the medical officer requesting the examination.

The specialist must never attempt to interpret films, nor to discuss such films with the patient or the patient's family. If a patient attempts to pry information concerning his examination or the state of his health, he should be politely told to refer his questions to the proper medical authority.

The specialist must not hold unnecessary conversations within the hearing of patients or members of any patient's family. A word heard, here and there, can easily be misconstrued. Loose talk is not permissible and may do considerable harm.

Patients must never be allowed to see their films or their examination reports. On the other hand, the specialist should make every effort, within prescribed policy of the clinic, to help the medical officers of other services to obtain films and reports on their respective cases.

The X-ray specialist may not submit articles for publication or read papers before the public on subjects dealing with roentgenography unless officially authorized to do so.

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*This instructor's manuscript supersedes IM 38-520-128, 090

1535

It is essential to practice promptness and courtesy in answering telephones. Personnel should state the name of their office, their grade, and their last name--for example, "X-Ray Clinic, Specialist Jones speaking. The individual answering the telephone should get the name and the desires of the caller. If the call is for an appointment, it should be arranged in consultation with the radiologist or NCOIC and noted in the appointment book. If the call is for the radiologist and he cannot answer the phone at that time, arrangements should be made to complete the call later. While only the radiologist or his professional staff may give diagnostic information over the telephone, the specialist may give wet readings or emergency reports to the medical officers from other services, when specifically authorized to do so by the radiologist.

Medical ethics is a monument of honor we erect by complying with the rules and principles which govern our conduct toward patients whom we assist during their hospitalization. You will keep yourselves well informed concerning the rules of conduct peculiar to your duties as X-ray specialists, and by using good common sense at all times, it will enable you to render service long remembered by the patients you assist, whether they be ambulatory or in strait jackets.

If, in the conduct of an examination, the specialist should make a mistake, he must report it immediately to the radiologist. The radiologist, being directly responsible for the welfare of the patient, must be able to depend upon the absolute honesty and integrity of the X-ray specialist in carrying out his orders. The specialist must be ever mindful that the patient is above all else in importance, and he must do nothing that will jeopardize the patient's chances of recovery.

The X-ray specialist must be as military in appearance and conduct as any other soldier and must adhere to the rules of military courtesy and discipline. The true soldier--with an erect carriage, neat precise dress, prompt and exact attention to duty, and a cheerful attitude toward all those with whom he comes in contact--will inspire confidence in patients.

The duties of an X-ray specialist require handling the greater number of patients; therefore, the specialist must realize, first of all, that he is dealing with ill and injured people. They may be in intense pain, acute discomfort, or under considerable emotional stress. Some patients may be irritable, demanding, or unreasonable. A quiet manner and a dignified, businesslike approach will create confidence and help gain the patient's cooperation. Kindness, tact, understanding, and simple courtesy are the most effective "tools" the specialist can use in dealing with patients. If the specialist practices the principles of good interpersonal relations in DA Pamphlet 8-13, he will be able to give the best possible service to the patient.

In instructing the patient about the examination, the specialist

1536

should speak clearly and distinctly, as some patients may be hard of hearing. A simple, brief explanation of the positioning to be used will put the patient at ease. If the patient knows what to expect and what is expected of him during the examination, he will be less apt to become apprehensive, critical, or demanding.

Aged and weak patients should be kept well-covered on cold days and in air-conditioned environments. Senile patients should be watched as carefully as children; they must never be left unattended.

You will be required to lift patients from litters, wheelchairs, and beds, and place them in positions suitable for radiographic exposures. All such handling must be appropriate to the needs of the occasion; for example, it would be absolutely unnecessary to position any type of ankle injury as though you were wringing a chicken's neck. The specialist must be careful not to offend the patient's sensibilities and sense of modesty. When necessary to establish the location of palpation points during an examination, the specialist should warn the patient in advance that he is going to touch a specific area on the patient's body.

Patients should always be addressed by their appropriate rank or title.

The management of medical affairs are established by your hospital commander. You will experience a change of such procedures from one clinic or hospital to another. After reading these standard operating procedures you should have no difficulty in rendering a service that will be a credit to any institution. For example--in dealing with female patients, the male X-ray specialist must be especially careful to avoid any unnecessary exposure of the patient. When the patient is a female and the examiner is a male, a female attendant must be present. The policy of chaperonage in such cases will be prescribed in local regulations.

It is imperative that a high standard of cleanliness be maintained in the clinic. Good hygienic conditions are necessary not only for the health and comfort of the patient, but also for the welfare of duty personnel.

The entire person of the X-ray specialist must be scrupulousely clean. This requires daily baths and changes of underwear, a clean regulation uniform at frequent intervals, a daily shave, and frequent haircuts. The hands and nails need particular attention. The hands should be washed thoroughly after each patient, and whenever the specialist has had contact with excreta to prevent bacteria and contamination on the specialist's hands from being carried to patients, X-ray equipment, and other articles. The care of the mouth is also important--a malodorous breath is offensive, not only to patients but to coworkers. The X-ray specialist must never smoke in the radiographic or fluoroscopic rooms or while working with patients. Neither should the specialist smoke to the extent that tobacco

/537

odor clings to his clothing. He must observe all "no smoking" rules. If he has reason to suspect that he has been exposed to an infectious or contagious disease, he should inform his immediate superior right away.

Proper well-kept equipment and surroundings are also conducive to the best efforts of the individuals concerned. The X-ray clinic must be kept ready for inspection at all times. This includes airing the clinic, dusting, attending to the linen supply, and making all necessary arrangements to care for the incoming patients. Then steps must be taken to see that the clinic is kept clean and orderly throughout the day. The clinic must be cleaned thoroughly at the end of each day, all waste and trash cans emptied, soiled linen prepared for exchange, and items of supply checked to make sure that a sufficient quantity is on hand for the next day.

The specialist is personally responsible for the care of the roentgenographic room to which he is assigned and for the proper care and use of the equipment which it contains. This room must be kept as clean as any other room used for medical purposes. All items of equipment which come in contact with the patient must be kept scrupulously clean, and should be wiped off with a disinfectant after each procedure has been completed. The X-ray specialist must realize that he is engaged in caring for the sick and follow carefully the rules of medical asepsis, sterilization, and sanitation. The specialist should have the room completely prepared for the examination, with all accessories at hand before the patient is brought in. All linens should be fresh, and there should be no sign of disorder from the previous examination.

You are nearing the end of your training. You are well qualified to assist the radiologist. Later, some or perhaps all of you will be licensed in this specialty, but qualification or possession of a license, diploma, etc., does not guarantee protection to your patients. It cannot, because caring for the sick becomes a moral obligation depending upon your individual integrity as an X-ray specialist.

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*LP 38-520-119
036

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE & SURGERY
X-RAY BRANCH

Soft Tissue (1 hour)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES: TM 8-280

STUDY ASSIGNMENT: After Class Review TM 8-280, pp 13-48 thru 13-50

STUDENT UNIFORM AND EQUIPMENT: TM 8-280

TOOLS, EQUIPMENT, AND MATERIALS: None

PERSONNEL: One instructor from X-ray Branch (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Radiographs demonstrating soft tissue technique; a sufficient amount of radiographic illuminators; soft tissue factors (see Annex A); chalk, chalkboard, eraser and pointer

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Lecture

I. INTRODUCTION (5 min)

A. Opening Statement: It is essential that the X-ray Specialist have an understanding of soft tissue radiography, and upon request by the radiologist, have the capability to produce a diagnostic X-ray film.

B. Objectives

1. List the MA, KVP, and time range used in soft tissue radiography.

2. State the accessory equipment used in soft tissue radiography.

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*This lesson plan supersedes LP 38-520-119, 090

3. Properly position and handle patients with the least amount of embarrassment.

4. Describe the type of film used in mammography examinations.

C. Class Procedure and Lesson Tie-in

None.

II. EXPLANATION (35 min)

A. Definition and Purpose

NOTE: Place two films on view box, one of soft tissue and one of bone detail and explain the difference between the two.

B. Exposure Factors

1. High MAS

2. Low KVP range

3. Short exposure time

NOTE: The exposure factors are very critical and must be exact.

NOTE: Write exposure factors from Annex A on chalkboard for students to copy.

C. Machine and Accessory Devices

1. Accurate voltage regulator

2. Small focal spot

3. No added filters

4. Cones and diaphragms

5. Full wave rectification

6. Rotating anode

NOTE: Positions used in soft tissue radiography will be basic X-ray positions.

QUESTION: What are the factors used in soft tissue radiography?

ANSWER: Low KVP, high MAS.

QUESTION: Why is a low KVP and high MAS used?

ANSWER: To obtain a short scale of contrast.

D. Darkroom Procedure

1. Processing solutions
2. Lighting

NOTE: Consistent darkroom procedure must be followed to eliminate the possibilities of artifacts.

QUESTION: Why do we want to use machines that have a higher output?

ANSWER: So we can use the shortest exposure time possible and still obtain our higher MAS.

E. Mammography

NOTE: Radiographic examination of the breast to demonstrate radiolucent and radiopaque tumors and masses and any other pathology.

1. Routine positions
    a. Craniocaudad
    b. Mediolateral
    c. Axillary

QUESTION: What are the radiographic mammography positions used?

ANSWER: Generally, your clinic will dictate the positions required. The usual views will be--craniocaudad, mediolateral, and axillary views.

2. Patient preparation and handling
    a. Local anesthetic

1541

b. Injection of media

(1) Carbon dioxide

(2) Diodrast 35 percent

3. Examination

a. Soft tissue

b. Infrared photography

c. Radiographic

QUESTION: What is the most important consideration when handling these patients?

ANSWER: Care must always be taken to prevent any undue embarrassment.

F. Questions From Students

NOTE: Make after class assignment--study TM 8-280, 13-48 thru 13-50

III. SUMMARY (5 min)

A. Review of Main Points

1. Purpose

2. Exposure factors

3. Machine and accessory devices

4. Darkroom procedures

5. Mammography

a. Routine positions

b. Patient preparation and handling

c. Type of examination

B. Closing Statement: Examinations, specifically for soft tissue, are often performed in most clinics. The exact procedures and methods used will vary, but the basic principles of contrast, detail, and consistency will stay the same.

ANNEX A
INSTRUCTIONAL AIDS

Soft Tissue Factors

Starting factors for soft tissue examination using full-wave machines, nongrid.

Part	KVP	Milliampere-seconds	FFD
Hand and wrist	25	150	40"
Elbow and ankle	30	175	40"
Humerus	28	200	40"
Leg	32	175	40"
Knee	32	200	40"
Thigh	40	200	40"
Neck	36	175	40"
Neck, lateral	36	250	48"
Breast	30-34	175	40"

NOTE: In cases where a self-rectified mobile unit is used, careful immobilization is stressed.

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X-RAY BRANCH

Soft Tissue

It is essential that the X-ray specialist have an understanding of soft tissue radiography, and upon request by the radiologist, have the capability to produce a diagnostic X-ray film.

Soft tissue radiography is a procedure whereby the associated technical factors are balanced to produce a radiograph which provides optimum demonstration of the essential details within the soft tissue structure under consideration. Radiographs of some parts of the body lend themselves more readily to this procedure than others. Anatomical parts, or areas having great differences in density, are less difficult to radiograph and allow for a considerable latitude in exposure factors. On the other hand, we must not overlook the fact that when a body part of soft tissue consists of adjacent overlying structures with each differing in density to an extent approaching imperceptibility; it will be necessary for you to employ the most exacting technique if maximum diagnostic quality is to be obtained. The film shows an image of the humerus on an average adult. The technical factors are adequate for the structural detail of bone. This next film, also of the humerus, demonstrates a shortening of the scale of contrast; the visibility of details within the soft tissue is increased, while osseous detail has decreased. It is the soft tissue demonstrated which makes this radiograph useful. The proper penetration of the soft tissue structure was determined by a decrease in kilovolts and an increase in MAS.

The vital principle of soft tissue radiography is to take full advantage of all of the factors which aid in the accomplishment of the primary objective, which is the optimum differentiation of the soft tissue details. Your technique must be selective for a specific area of soft tissue. The area of interest must be adequately penetrated by the rays. This you must realize is of utmost importance because your main objective is to produce differentiation of details within the soft tissue structure rather than merely an outline. The practical kilovoltage range is from 20 to 70 KVP, depending upon the thickness and density of the part. A good rule for you to remember is to use the lowest kilovoltage necessary for adequate penetration. Your soft tissue films should exhibit a relatively high short-scale contrast and the scale of contrast must graduate over the entire image portion of interest as seen in this lateral neck where the esophagus, thyroid cartilage, and trachea, as well as the hyoid bone is well demonstrated. Were this area, under study, to present a chalky appearance or completely devoid of silver, as in the area of the cervical spine, or if it were excessively dense, this film would be of no practical, diagnostic value.

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*This instructor's manuscript supersedes IM 38-520-1190, 090

To obtain the quality of radiographic contrast suitable for soft tissue radiography, you must consider six factors: First, always use a relatively high milliampere--second ratio with as low a kilovoltage as is consistent with adequate penetration for the particular soft tissue structure under consideration. Second, you must use the minimum exposure time possible, correct voltage regulator setting, small focal spot, hence increasing detail, rotating anode tube, and intensifying screens. The use of intensifying screens aids in obtaining contrast and also serves to help minimize the exposure time. You may, on occasion, use a cassette with a single back screen when using the very low kilovoltages as this will tend to eliminate disproportionate absorption of the remnant radiation; however, you will find the use of double screens is satisfactory in most cases.

Third, your best results will be demonstrated when filtration of the primary X-ray beam is at a minimum, especially if the tissue thickness is very small. Fourth, you will, at all times, use cones and diaphragms to limit the amount of irradiation to the part. This will lessen the amount of fogging secondary radiation. Fifth, your processing procedures are a part of the key to successful soft tissue results. Time-temperature development in fresh solutions of proper strength is imperative. Safelighting must conform to proper standards of darkroom illumination. You must use a good quality in-date film. Sixth, the use of a machine with full-wave rectification, with a rotating anode tube is preferred. It will help to minimize motion unsharpness by permitting a shorter exposure time.

On occasion, you will need to employ soft tissue examinations on body parts such as muscles for outlines of specific structures, areas of calcification; blood vessels; breast, with or without injections of contrast media; tumors for extent, location, etc.; gas gangrene for extent of involvement; foreign bodies, especially of the nonmetallic variety; and fracture sites for demonstration of early callus.

The detection of an abnormal condition always depends upon clear delineation of the tissues constituting the part, and no region requires a more highly specialized exposure technique for such delineation than does the breast. This is because of the similarity in physical density, the lack of adequate intrastructural contrast, the several types of soft tissue composing the breast, the extensive variations in size and shape, and the equally extensive physiologic changes that occur along the life cycle from youth to old age.

The examiner injects the breast under consideration with a local anesthetic and then injects one of two or both carbon dioxide or a sterile aqueous solution (preferred 35 percent diodrast). The injection of carbon dioxide is referred to as aeromammography and the gaseous medium is injected into the retromammary and premammary spaces to outline the breast matrix and to demonstrate radiopaque cysts and tumor masses. The opaque dye solution (diodrast 35 percent) is employed to demonstrate the duct tree and acini of individual lobes. The solution is introduced into the orifice of the main duct of each lobe to be investigated. In the survey examination, the unaffected breast is radiographed for comparison, the axilla is always included on the films of the respective breast because of the 20 to 30 large lymph nodes that drain the lymphatic vessels of the breast.

A soft tissue technique is desired, something on the order of 30 to 40 KVP, 175 to 200 MAS with a FFD of 36 or 40 inches. This gives the desired short scale of contrast desired because of the slight variation of part density.

Mammography techniques require that the X-ray transformer be adjusted or modified to deliver energies in the 20- to 40-kilovolt range at a specified current setting. Most of them require that the radiation be unfiltered; that is, that no filtration be added to that which is inherent in the X-ray tube. The focal-spot size is determined according to the current that is employed.

In the techniques in which a short focal-film distance is used, accurate centering of the beam of radiation necessitates the use of special mammography cones. These have one flat side with a semi-elliptical cutout at its distal end so that it can be adjusted over the breast in close approximation to the chest wall; this side of the cone is lined with lead for the protection of the adjacent intrathoracic structures. Mammography cones are available in 9- and 14-inch length, in sizes suitable for use with small, average, and large breasts. A 4- by 12-inch extension cone is used in the techniques in which a longer focal-film distance is used.

It is becoming more and more common to utilize infrared photography instead of radiography,

The radiographic positions will be dictated by your clinic. Most generally, the views will be craniocaudadal, mediolateral, and axillary. As stated previously, in survey films both breasts are examined for comparison. In all of the examinations aforementioned, only the side under consideration is uncovered. Care must be taken to insure that no undue embarrassment is caused the patient.

Examinations, specifically for soft tissue, are often performed in most clinics. The exact procedures and methods used will vary, but the basic principles of contrast, detail, and consistency will stay the same.

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X-RAY BRANCH

Examination of the Nervous System (3 hours)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES: TM 8-280

STUDY ASSIGNMENT: After class read TM 8-280, pp 14-54 thru 14-67.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280

TOOLS, EQUIPMENT, AND MATERIALS: None

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Radiographs of commonly performed exams of the nervous system; chalkboard, chalk, and eraser; radiographic illuminators and myelogram tray

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Lecture (3 hours)

1. INTRODUCTION (5 min)

   A. Opening Statement: Our nervous system is an amazingly complex apparatus. It is most efficient, but when a lesion or other pathology exists, it requires the most competent and delicate surgical correction. Through the use of sophisticated equipment and techniques, more and better radiographs of tumors and other abnormalities are produce. As X-ray Specialists and part of a team it is our job to provide the required radiographs of the area being examined.

   B. Objectives

      1. Identify the examinations of the nervous system.

      2. List the contrast media used in each examination of the nervous system.

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*This lesson plan supersedes LP 38-520-125, 090.

3. After practice provide competent assistance to Medical Officer or Radiologist in performing these examinations.

4. List site of injections for examinations of the nervous system.

5. List the purpose for each examination of the nervous system.

C. Class Procedures and Lesson Tie-in

None

II. EXPLANATION (125 min)

A. Myelogram

1. Definition: The fluoroscopic and radiographic examination of the spinal cord and subarachnoid space following the introduction of a contrast medium.

2. Purpose

a. Detection of spinal cord tumors

b. Displacement of an intervertebral disc

3. Anatomy of spinal column

a. Spine

b. Subarachnoid space

c. Spinal cord

(1) Meninges

(2) Dura mater

(3) Arachnoid membrane

(4) Pia mater

4. Types of myelograms

a. Lumbar myelogram

b. Thoracic myelogram

c. Cervical myelogram

5. Contrast media

   a. Iodized oil (Pantopaque)

   b. Air or oxygen

NOTE: Contrast medium most commonly used is Pantopaque because it is less irritating. Hypaque may also be used in special cases.

6. Clinical procedure

   a. Preparation of patient

      (1) Patient is scheduled except for emergencies

      (2) Sedation is administered 1 hour prior to examination

      (3) Patient gowned with opening in back

   b. Preparation of fluoroscopic exposure room

      (1) Radiographic table horizontal with foot and shoulder rests

      (2) Fluoroscopic tube energized, set factors for spot films

      (3) Proper letter marker affixed to fluoro screen

      (4) Spot films available

      (5) Safety bar in place

      (6) Lead aprons and gloves available

      (7) Radiographic tube out of way

      (8) Acessory table for sterile tray positioned near the exposure table

      (9) Grid cassettes available

NOTE: Show and explain the sterile tray setup.

QUESTION: What opaque media are used in this examination?

ANSWER: Iodized oils are used. Pantopaque is the most common. Pantopaque is most preferred because it is less irritating.

c. Fluoroscopic procedure

(1) Patient position

(a) Left side--fetal position (most common)

(b) Prone, with pillows under lower abdominal region

(2) Sterile myelographic tray prepared

(3) Injection site made aseptic

(4) Lumbar puncture administered

(a) Level of L3-L4 or L5-SI

NOTE: An 18 to 20 G. spinal puncture, short beveled needle is inserted into the subarachnoid space directly in the midline.

(b) Cerebrospinal fluid removed-- 5 cc.

NOTE: The cerebrospinal fluid removed is collected in a test tube and sent to the medical laboratory to test for infection; e.g., meningitis and red blood cells.

(c) Contrast medium injected

(d) Patient carefully placed in a prone position

(e) Fluoroscopic screen placed over patient

NOTE: The specialist should be sure that the fluoroscopic screen is locked. Proper precautions must be taken to avoid disturbing the position of the needle.

(f) Fluoroscopic procedure

NOTE: Radiographic positions will be designated by the radiologist.

(g) Radiographic procedure

NOTE: Following the radiographic positions, the medium must be removed. The patient is prone, the table is tilted until the opaque medium is pooled under the needle. (Under fluoroscopic control.) A syringe is then attached to the needle and the contrast medium is carefully aspirated.

NOTE: A demonstration showing how the dye will gravitate to the lowest level.

NOTE: Show radiographs to the radiologist as soon as wet processing is complete.

B. Ventriculography

1. Definition

A diagnostic procedure whereby a series of radiographs are made of the head in predetermined positions following the removal of all or a portion of the cerebrospinal fluid from the ventricles and its replacement with a suitable contrast medium

2. Purpose

a. Demonstrate abnormal displacement, size, and shape of the ventricles

b. Provide evidence if increased intracranial pressure is suspected

3. Review of anatomy of brain

a. Cerebrum

b. Cerebellum

c. Pons

d. Medulla oblongata

e. Ventricles--detailed anatomical review

f. Meninges

NOTE: Make a chalk drawing of the ventricles, superior-inferior view and a lateral view.

4. Preparation and scheduling

    a. Scheduled except for emergencies

    b. Sedated the night before

    c. Sedated again 1 hour prior to examination

    d. Breakfast withheld the morning of examination

5. Operative procedure

    a. Patient in sitting position, rest under chin

    b. Aseptic preparation

NOTE: Show tray.

    c. Local anesthetic

    d. Trephine openings

NOTE: Trephine openings are made 6.5 to 7 cm. above the external occipital protuberance and 3 cm. lateral to the midline.

NOTE: Small children--needle or cannula introduced between the sutures of skull without trephine.

    e. Needle or cannula introduced

    f. Mercury manometer

NOTE: Mercury manometer used to measure the intracranial pressure.

    g. Cerebrospinal fluid collected for measuring

        (1) Drainage method (two needles)

1552

NOTE: The patient's head is positioned so that one cannula is lower than the other, to permit the cerebrospinal fluid to drain from the lower cannula while air (the contrast medium) flows into the ventricular system through the upper cannula. This procedure continues until 25 to 30 cc. of the fluid is removed and replaced with air.

(2) Aspiration method (one needle)

NOTE: Small quantities of cerebrospinal fluid are withdrawn (5 to 10 cc. at a time) with a luer type syringe attached to the cannula with a flexible tubing and replaced with pure oxygen until gas instead of fluid is returned on aspiration.

a. Cannulas removed

b. Scalp sutured

c. Dressing applied

d. Patient brought to X-ray Clinic

6. Radiographic procedure

a. AP, PA, left and right laterals

NOTE: Describe autotomogram procedure for visualization of fourth ventricle.

(1) Patient horizontal

(2) Patient sitting

NOTE: Describe decubitus positions taken for air/fluid level.

b. Technical factors

(1) Grid technique

(2) Short time of exposure

c. Additional views as requested by the Radiologist

1553

C. Pneumoencephalography

1. Definition: Radiographic examination of the cerebral structures following the removal of cerebrospinal fluid and its replacement with air or other gas by means of lumbar or cisternal puncture.

2. Purpose

a. Demonstrate abnormal displacement, size, and shape of the ventricles

b. Provide evidence if increased intracranial pressure is suspected

NOTE: Scheduling is the same as for ventriculography.

3. Lumbar puncture method

a. Patient is properly gowned and seated facing Potter-Bucky diaphragm

NOTE: EMESIS BASIN SHOULD BE IMMEDIATELY AVAILABLE FOR USE IF PATIENT BECOMES NAUSEATED.

b. Spinal puncture is made at level of L3-L4

c. Cerebrospinal fluid is removed

d. Contrast medium of air or gas is injected

NOTE: Five to ten cc of fluid may be removed and replaced with the same amount of gas or air. This is done in order to fully visualize the ventricles.

e. Radiographs as requested by the Radiologist are then taken

4. Cisternal puncture method

a. Patient properly gowned and sitting facing Potter-Bucky diaphragm

b. Head must be rigidly immobilized

c. Spinal puncture superior to spinous process of axis

NOTE: The needle is advanced into the cisterna magna until the tip of needle lies at the level of the posterior margin of the foramen magnum.

1552

    d. Fluid removed

    e. Fluid replaced with a double volume of oxygen

    f. Radiographs are taken as directed by Radiologist

5. Precautions

    a. Patient must be observed for the following:

        (1) Severe headaches

        (2) Nausea

        (3) Profuse sweating

        (4) Fainting

    b. Prevent patient from sliding off table

    c. Patient must be accompanied back to the ward

    d. Patient must be transported on a litter

6. Body absorption of contrast media

    a. Gas: 12 to 72 hours, or longer

    b. Followup films may be required

    c. Films must be accurately identified

__NOTE__: IMPORTANT--the X-ray Department is responsible for the care of the patient until he is back on the ward or in the care of a ward attendant.

__QUESTION__: What is the contrast media used in pneumoencephalography?

__ANSWER__: Air or oxygen.

__QUESTION__: How long does it take for the body to absorb the contrast media?

__ANSWER__: From 12 to 72 hours.

__QUESTION__: Ventriculography is a demonstration of what?

__ANSWER__: The ventricles of the brain.

QUESTION: A radiograph shows displacement of a vertebrae. What is the name of the examination?

ANSWER: Myelography.

QUESTION: Where is the entrance site for the contrast media for ventriculography?

ANSWER: Through trephine holes in the skull.

NOTE: Make Assignment: After Class Study TM 8-280, pp 14-54 thru 14-67.

D. Questions From Students

III. SUMMARY (5 min)

A. Review of Main Points

1. Anatomy
2. Point of entrance for contrast media
3. Contrast media for each examination
4. Position of patient for examination

B. Closing Statement: The examinations which we have discussed are highly critical examinations of the spinal cord and subarachnoid spaces. As X-ray Specialists in the Military Forces, you must be prepared to render valuable aid in preparing the exposure room, getting the correct contrast media, and helping the Radiologist in every way to complete these examinations.

1556

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Examination of the Nervous System

Our nervous system is an amazingly complex apparatus. It is most efficient, but when a lesion or other pathology exists, it requires the most competent and delicate surgical correction. Through the use of sophisticated equipment and techniques, more and better radiographs of tumors and other abnormalities are produced. As X-ray Specialists and part of a team it is our job to provide the required radiographs of the area being examined.

A myelogram is the flouroscopic and radiographic examination of the spinal cord and subarachnoid space following the introduction of a contrast medium.

Myelograms are used to demonstrate the area of pressure on the spinal cord caused by a ruptured intervertebral disc and to aid in the localization of spinal cord tumors.

The spinal canal is so situated that it can be used as a constant for two elements. They are first, the spinal cord which is contained within the canal; and second, the vertebral column which surrounds the canal.

There are several different types of myelograms, lumbar, thoracic, cervical, and pneumomyelograms (when air or oxygen is used as the contrast medium).

Pantopaque (ethyliodophenylundecylenate), an oil iodinated organic compound, is the preferred contrast media for myelograms. However, in some localities, or in special situations, substances in the sterile aqueous category (e.g., Hypaque) may be used. The discussion here will be limited to those techniques in which Pantopaque is used. Air or oxygen is used as the contrast media for pneumomyelograms.

Except in cases of emergency, myelograms are scheduled according to established clinical procedure. Sedation is administered by the responsible clinician approximately 1 hour prior to the procedure.

Upon arrival at the X-ray Department, the patient is properly gowned for the examination, and the procedure is explained to him.

Before the patient is brought into the fluoroscopic exposure room, the Specialist should prepare the room. The radiographic table should be horizontal with foot and shoulder rests in place; the fluoroscopic tube

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*This IM supersedes IM 38-520-125, 090

1557

should be energized with fluoroscopic and spot film factors set; spot films placed in a convenient place; lead aprons and gloves for doctors and technicians; radiographic tube should be moved out of the way and a table for the surgical tray positioned near the exposure table.

The patient is placed on the horizontal radiographic-fluoroscopic tilt-table unit, either prone or on his side, depending upon the preference of the examiner. If preliminary radiography is not required, the positioning procedure is as follows: The patient is adjusted in the prone position for the lumbar puncture with the midline of the body aligned to the center of the table; the head may be turned to either side. The patient is then instructed to grasp the edge of the table with both hands, at the level of his shoulders; or to grasp the shoulder rest with one hand. To straighten the lumbar curve to the required degree, a bolster (made by rolling a small pillow, or other suitable object, into the desired shape) is placed under the lower abdomen. The patient's feet are placed firmly against the footrest.

A second method of positioning for lumbar puncture is as follows: The patient lies on his side, with his back toward the examiner. A suitable bolster is placed under the thoracic region, to straighten the spinal column in relation to the midsagittal plane and make it parallel with the tabletop. The patient's neck, body, and lower extremities are brought into flexion, so that the knees are drawn toward the chin and the arms and shoulders are drawn forward.

A sterile myelographic layout is set up near the examiner by the technologist and the fluoroscopic safety bar is put in place.

The injection site is made aseptic by the examiner or an assistant, and local anesthesia is administered. Sterile precautions are observed throughout the entire procedure.

The examiner inserts an 18 to 20 gauge lumbar-puncture short-beveled needle into the subarachnoid space, exactly in the midline and in the region on the vertebral interspaces between L3 and L4, L4 and L5, or L5 and S1. The stilette is removed from the needle, and approximately 3 to 5 cc. of cerebrospinal fluid is withdrawn and collected in a test tube for laboratory analysis. This is sent to the pathology Department of the hospital.

If the patient is lying on his side, he must be adjusted in the prone position. The injection site is covered with sterile gauze or a towel. The fluoroscopic screen assembly and spot-film device are then brought into operative position over the injection site. Proper precautions must be taken to avoid disturbing the position of the needle. The Specialist should be sure that the fluoroscopic screen is locked, and that the locking mechanism is absolutely safe. The head-end of the table is now raised approximately 10 to 20 degrees from the horizontal.

A syringe, filled with the contrast medium (3 to 6 cc.) is attached to the needle. After introduction of the contrast medium into the subarachnoid space, the syringe is disengaged from the needle, the stilette is replaced, and the injection site is covered with sterile gauze or a towel. The bolster is removed from beneath the abdomen and placed under the patient's lower extremities, as needed.

The fluoroscopic screen and spot-film device are brought into working position over the injection site. The apparent shape, location, and behavior of the body of injected contrast medium is studied by the examiner under fluoroscopic control, as the head-end of the table unit is raised or lowered according to his instructions. The position of the patient, in relation to the tabletop, may be changed at intervals; for example, the patient may be obliqued either to the right or to the left, or postured on his side. In handling the patient, great care must be taken to see that the needle does not hit the fluoroscopic screen assembly. NOTE: Proper letter marker should be attached to fluoroscopic screen prior to examination.

Spot-film exposures are made at various intervals and in different positions. The patient should be instructed beforehand that he is to immediately suspend respiration at a given signal from the examiner or the X-ray Specialist. In addition to the spot-films PA and cross table lateral views may be taken without changing the position of the patient. Spot oblique views and steroscopic exposures are made as indicated by the examiner.

Following radiographic positions, the medium must be removed. The patient is prone, the table is tilted until the opaque medium is pooled under the needle, under fluoroscopic control. A syringe is then attached to the needle and the contrast medium is carefully aspirated.

Ventriculography is a diagnostic procedure whereby series of radiographs are made of the head in several positions following the removal of all or a certain portion of the cerebrospinal fluid from the ventricles and its replacement with a suitable contrast medium.

The purpose of a ventriculogram is to demonstrate abnormal displacement, size, and shape of the ventricles and when there is evidence of increased intracranial pressure.

The first and the second ventricles are the lateral ventricles. They lie within the cerebral hemispheres. Each lateral ventricle consists of a body and two horns; one horn extends into the frontal lobe and the other into the temporal lobe. The interventricular foramina are communicating channels between the two lateral ventricles and the third ventricle. The third ventricles is a narrow cleft which communicates with the fourth ventricle by way of the cerebral aqueduct. From the fourth ventricle there are three openings into the cranial subarachnoid space; the two lateral openings are called the foramen of Luschka, and the medial one is called the foramen of Magendie. The fourth ventricle connects with the central canal of the spinal cord. The fourth ventricle is visualized laterally using the autotomogram method, a long exposure time, while the technician rotates head slightly from side to side to achieve tomogram effect.

The preparation and scheduling of these patients is done in advance of the examination, except in cases of emergency. Usually, the patient is sedated the evening before and again on the morning of the examination. Breakfast is withheld on the morning of the examination.

The patient is taken to the designated operating room, where he is placed in a sitting position with his chin resting on a suitable support. After aseptic preparation and administration of local anesthetic by the attending doctor, he will make two small trephine openings in the skull, 6.5 to 7 cm. above the occipital protuberance and 3 cm. lateral to the midline. A needle or cannula is introduced into each of the trephine openings, and then advanced into the ventricular cavities. You will notice a mercury manometer being used to measure the intracranial pressure. When the patient is in a recumbent position, the normal manometer range reading is 110 to 175 mm.

About 1 cc. of indigo carmine is injected into one of the ventricles and is allowed to drain slowly to diffuse for several minutes. Indigo carmine is a nontoxic coloring substance that mixes with the cerebrospinal fluid. To promote drainage, the patient's head is positioned so that the exposed portions of the cannulas are dependent. The patient's head is then positioned so that one cannula is lower than the other, to permit the cerebrospinal fluid to drain from the lower cannula while air (the contrast medium) flows into the ventricular system through the upper cannula. This procedure is continued until approximately 25 to 30 cc. of the cerebrospinal fluid has been withdrawn and replaced with air, or drainage of the cerebrospinal fluid may be accomplished by means of a syringe (Luer type) attached to the cannula with flexible tubing. In this method, small quantities of cerebrospinal fluid are withdrawn (5 to 10 cc. at a time) and replaced with pure oxygen. This procedure is continued until gas instead of fluid is returned upon aspiration.

When the injection of the contrast medium has been completed, the cannulas are removed, the scalp is sutured, and a dressing is applied. Immediately following this, the patient is brought to the X-ray room for the ventriculographic examination.

Ordinarily, AP, PA, and right and left lateral views of the skull are made with the patient in the horizontal position; then a similar set is made with the patient in an upright position. The exposure factors are usually the same as those used for routine skull examinations using short exposure time.

For the sagittal view, the vertically or horizonaally projected CR is directed along the infraorbital medial line and in line with the midsagittal plane of the skull. The lateral views are made similar to routine views of the skull.

A number of other views and projections can be ordered by the Radiologist. These are prone and supine positions of the patient with the CR directed horizontally and right or left lateral views with the patient prone or supine. Stereoscopic views are frequently made during this difficult and challenging procedure.

When possible, grid technique should be used for all ventriculographic exposures. If a special head unit is not available, it may be necessary to use grid-front cassettes or a wafer-type grid for the right angle views. Customarily, a pair of right angle views is made in each head position used. Ideally, each pair should be made without changing the position of the patient's head, for even a slight deviation in position may change the distribution of the cerebrospinal fluid and the contrast medium within the ventricular system--resulting in dissimilarity of object-representation between the sagittal and lateral views.

To obtain the best results, the patient must be properly immobilized and must suspend respiration during exposure of the films. The positioning of the head and the centering of the CR must be done with extreme care. The MA-time factors selected should be such as to allow use of the shortest possible exposure time. Arrangements must be made for the films to be processed immediately and presented to the Radiologist for reading before the patient leaves the X-ray Department. The entire procedure must be under aseptic conditions.

One of the variations in this examination is called ventriculoencephalography. It is used to demonstrate structures in the posterior fossa which cannot be shown clearly by regular ventriculography. This method is accomplished by means of a spinal puncture where a certain amount of cerebrospinal fluid is withdrawn and replaced with air or gas. The necessary films are ordered by the examiner.

The other method is called radiopaque contrast ventriculography where a contrast medium is introduced into selected portions of the ventricular system. Films are then made in several positions. If this procedure becomes necessary, it is usually performed following gas ventriculography.

1561

Pneumoencephalography is the term applied to the radiographic examination of the cerebral structures following the removal of cerebrospinal fluid from the ventricles and its replacement with air or other gas by means of lumbar or cisternal puncture.

The examination is scheduled except in the event of an emergency.

The patient is sedated the evening before and on the morning of the examination breakfast is withheld. The male patients will be disrobed to the waist. Female patients should be gowned so that the back may be exposed for spinal puncture.

Normally, the patient is seated in front of a Potter-Bucky diaphragm. A regular straight-back chair may be used. A sterile pneumoencephalographic tray will be obtained and set up in advance. The lumbar region of the patient is made sterile and draped, leaving only the area for spinal puncture.

One of the methods of introduction of contrast media, by lumbar puncture, is the two-needle method. You will be instructed to assist in adjusting the posture of the patient. The doctor will then insert a special type needle into the spinal canal between the fourth and fifth lumbar vertebrae. At this point a pressure reading is taken. Then, a second needle is inserted into the spinal canal between the third and fourth lumbar vertebrae. The flow of cerebrospinal fluid from the needles is noted. A manometer is connected to the upper needle in order that pressure readings can be made at various stages of the procedure. The films which you are instructed to take will be processed immediately and shown to the examiner for evaluation.

Another method is the single-needle method. This procedure is essentially the same as the two-needle method except that a different type needle is equipped with a multichanneled stopcock device which provides for removal of the cerebrospinal fluid, injection of the gas, and connection of the manometer.

In the cisternal puncture method, the patient is seated, facing a vertical Potter-Bucky diaphragm. The patient's head will be adjusted according to instructions from the examiner. The position of the head must not change. It must be rigidly immobilized. Under local anesthesia, a special type needle is introduced in the midline, just superior to the spinous process of the axis. The needle is then advanced into the cisterna magna until the tip of the needle lies at the level of the posterior margin of the foramen magnum. When the cerebrospinal fluid flows from the needle, the fluid is collected and replaced with double the volume of oxygen. At this time you would be directed to make films in various positions, generally PA and lateral without disturbing the patient's head or the needle. Some of the gas

1562

is then released in order to give the patient relief from intracranial hypertension. The syringe is again connected, the injection procedure is repeated, and the necessary radiographs are taken at the direction of the examiner.

Ordinarily, views of the skull similar to those used in ventriculography are made, the first set with the patient in an upright position and the second set with the patient in a horizontal position. Other views may be requested by the examiner. Stereoscopic views and grid technique are the same as for ventriculography. Body-section technique is sometimes used. This requires great care in positioning and postural manipulation, the sequence of positions and exposure, the exact layer to be demonstrated, and the time during various positions to allow for disposition of gas and cerebrospinal fluid within the intracranial cavities.

You will be asked to assist in the manipulation of the patient's head, for example, moving his head to the right, to the left, backwards or forwards, which must be done with exactness in order that the examination be a success.

The precautionary measures are the same as for ventriculography. In addition, you will observe these patients during the examination for reactions such as severe headache, nausea, vomiting, profuse sweating or faintness to prevent the patient from sliding down or off the table. An emesis basin and cleansing tissue must be kept at hand ready for use. Your patients must never be allowed to return to the ward unaccompanied. They should be returned by litter and explicit instructions obtained from the physician as to how the patient is to be positioned in his recovery bed. IMPORTANT: The X-ray department is responsible for the care of the patient until he is back on the ward or in the care of a ward attendant.

Inasmuch as the contrast medium (gas) is absorbed at periods ranging from approximately 12 to 72 hours--or even considerably longer--after its introduction, followup radiographs may be requested by the examiner. All followup pneumoencephalograms must be properly identified. This is done by appropriately labeling and marking the films to show the date and hour (and the position) which they were taken.

The examinations which we have discussed are highly critical examinations of the spinal cord and subarachnoid spaces. As an X-ray Specialist in the Military Forces, you must be prepared to render valuable aid in preparing the exposure room, getting the correct contrast media, and helping the Radiologist in every way to complete these exams.

SFC WILLIAM HORNIG
*LP 38-520-126
046

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE & SURGERY
X-RAY BRANCH

Skeletal Surveys and Scanography (2 hours)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES: TM 8-280, pp 13-16 thru 13-19.

STUDY ASSIGNMENT: After class, study TM 8-280, pp 13-16 thru 13-19.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280

TOOLS, EQUIPMENT, AND MATERIALS: None

PERSONNEL: One instructor (MOS 91P4H or 91P2H)

INSTRUCTIONAL AIDS: Chalkboard, chalk, eraser, and pointer; radiographs of skeletal surveys and scanograms; suggested survey routines (See Annex A)

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Lecture

I. INTRODUCTION (5 min)

A. Opening Statement: One of the most important yet frequently overlooked aspects of radiography, deals with the skeleton as a system rather than as a unit made up of individual components. We usually think of making a radiograph of a hand or foot, or some other bony part or region as a result of some injury. We give no thought at all to the skeleton as a whole, or of its functions. You must realize, however, that sometimes causes other than trauma may impair the function of the skeletal system. The soldier is no exception and many times the medical officer may order a skeletal survey for one of several reasons. You should be ready to do your utmost to assist in the recovery of the patient to useful duty.

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*This lesson plan supersedes LP 38-520-126, 090.

1564

B. Objectives

1. List the surveys associated with the skeletal system.

2. State the purpose of each separate skeletal survey and of scanography.

3. List and describe the procedure for the different skeletal surveys and for scanography.

C. Class Procedure and Lesson Tie-in

None

II. EXPLANATION (80 min)

A. Skeletal System Surveys

1. Definition: Radiography of any abnormal formation of the bony structures of the skeleton as a system.

2. Specific Surveys

a. Arthritic survey

(1) Purpose - to diagnose bone deformities caused by arthritis

(2) Areas examined - all areas of articulation

NOTE: A PA chest is taken for all surveys.

QUESTION: What areas are primarily considered for examination for arthritis?

ANSWER: The joint spaces.

b. Metastatic survey

(1) Purpose - to demonstrate any spread of disease from one area to another (Metastasis)

(2) Areas examined

(a) Bone

(b) Soft tissue

QUESTION: Why do we include soft tissues in this examination?

ANSWER: To see if any disease has spread to these areas.

c. Bone age survey

  (1) Purpose - to determine if there is any deviation of development age to chronological age

  (2) Areas examined

    (a) Children - birth to 5 years - DP of both feet

    (b) Children - 6 to 12 years, or older - PA of both wrists

QUESTION: What is the purpose of the bone age survey?

ANSWER: A comparison of chronological age to development age.

d. Pre-and postelectric shock therapy survey

  (1) Purpose

    (a) To diagnose any injury before or after the shock treatment

    (b) To decide whether the patient can undergo the shock treatment

  (2) Areas examined - vertebral column and skull

QUESTION: Why are the same views taken before and after therapy?

ANSWER: To establish whether or not the patient suffered any physical damage.

e. Long bone survey

  (1) Purpose

    (a) Diagnose malformations of long bones caused by disease e.g. scurvy or rickets

    (b) Differentiate between anatomical and functional abnormalities.

(2) Areas examined - bilateral extremities

B. Scanography - Orthoradiography

1. Reason for examination - to get an accurate measurement of long bones

2. Areas examined - lower and upper extremity

3. Methods

a. FFD 6 to 7 feet

b. Spot scanography - single coned exposure over each joint

c. Spot scanography in combination with calibrated rule.

(1) Bell-Thompson Ruler

(2) A 14 by 17 inch cassette in the bucky tray.

(3) Exposure method

d. Slit scanography

(1) Narrow slit as a conefield

(2) Tube travels over entire length of part

(3) 5 to 10 second exposure

QUESTION: What is the purpose of a scanogram?

ANSWER: To get an accurate measurement of the length of long bones.

D. Questions From Students

NOTE: Make assignment, Study TM 8-280, pp 13-16 thru 13-19.

III. SUMMARY (5 min)

A. Review of Main Points

1. Specific skeletal surveys

a. Arthritic survey

b. Metastatic survey

c. Bone age survey

d. Pre and post electric shock therapy survey

e. Long bone survey

2. Scanography

B. Closing Statement: These various surveys are performed routinely in large Army X-ray clinics. If you are to properly perform your duties as an X-ray Specialist, a thorough knowledge of each survey is essential.

ANNEX A
INSTRUCTIONAL AIDS

Suggested Survey Routines

NOTE: Place the following on the chalkboard for the class to copy into their notes. Be very emphatic in stating that these routines contain the maximum number of views usually required for these surveys and are to be used only when no specific routine is posted in the clinics the technician is working in or when the radiologist or referring physician fail to specify any particular positions and cannot be easily contacted to determine their wishes on the matter.

Arthritic Joint Survey

AP and Lateral	Lateral Only	One View Only
Elbows	Cervical	PA hand
Ankles	Dorsal	DA foot
Knees	Lumbar	AP shoulder
		AP pelvis

Also PA chest, if not previously taken

Metastatic Survey

Lateral Only

Skull
Cervical
Dorsal
Lumbar

Also PA chest, if not previously taken

Long Bone Survey

AP only

Humerus Both (Full Length)
Femora (Distal)
Pelvis (For hips)

Also PA chest, if not previously taken

1569

LP 38-520-126
046

Bone Age

Wrists (PA of both)
Feet (DP of both)

Also PA chest, if not previously taken

Pre- and Postelectrical Shock (Same for each)

Skull (AP and Lateral)
Dorsal (Lateral)
Lumbar (Lateral)

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*LP 38-520-126
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X-RAY BRANCH

Skeletal Surveys and Scanography

One of the most important yet frequently overlooked aspects of radiography is dealing with the skeleton as a system rather than as a unit made up of individual components. We usually think of making a radiograph of a hand or foot, or some other bony part or region as a result of some injury. We give no thought at all to the skeleton as a whole, or its functions. You must realize, however, that sometimes causes other than trauma may impair the function of the skeletal system. The soldier is no exception and many times the medical officer may order a skeletal survey for one of several reasons. You should be ready to do your utmost to assist in the recovery of the patient to useful duty.

By definition, radiography of the skeletal system is the interpretation of any abnormal formation of the bony structures of the skeleton. It is to demonstrate the general condition of the bony structures in regard to existing disease or functional status; to differentiate an anatomical short leg from a functional short leg; to diagnose the various bone deformities caused by diseases such as scurvy, rickets, or other vitamin deficiencies, and by the various arthritic conditions; to visualize any existing pathology that may have metastasized from one area to another, and to determine the bone age of an individual in comparison to his chronological age.

The associated word arthritis specifically means inflammation of the articulations. Therefore, it is obvious that this survey will be primarily used for any and all areas of articulation. The number of radiographs taken will be governed by the routine established in the specific clinic; However, the radiographs will always be taken of the primary joint spaces of the body. When a severe arthritic condition is found within one joint space of the body, it is plausible that other joint areas are also involved. In order to complete this survey clinically, it is usually customary to perform right-angle viewing of the specific areas in question.

The usual sequence of a highly infectious disease such as tuberculosis or cancer is to not only involve the immediate area, but also other areas of the body. This transfer of a disease from one organ to another is referred to as metastasis. It is found when this transfer does occur that it will involve primarily the shafts of bodies of bony structures. Therefore, the X-ray procedure will be compensated accordingly. In order for this examination to be completed successfully, the views taken must be such that they stress the primary areas of involvement, namely the bodies and shafts of the bony structures. Here too,

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*This instructor's manuscript supersedes IM 38-520-126, 090.

because metastasis may be accomplished to any area, a clinical routine must be established as to what specific views are to be taken and how many specific bones are to be included.

Another element that must be included in this routine that was not needed in the arthritic survey is that radiographs of organs or soft tissue surrounding the diseased areas must be taken in order to establish whether or not the pathology has spread to adjacent tissues. One of the most common areas of involvement are the lungs. These organs are very susceptible to a metastatic reaction.

Normally the body follows an average bone pattern in regard to ossification of certain areas or bones at specific time intervals. Any deviation from this average is considered abnormal and may be the means by which certain pathologies may be diagnosed. Ideally, films of the entire skeleton should be studied before the skeletal age is estimated. In daily clinical practice, the time-consuming, expensive roentgen examination of all the bones cannot be carried out except in special cases. For this reason, a small and convenient segment of the skeleton, commonly the wrist and hand, is considered representative of the entire skeleton in the assessment of the bone age. However, during the first months of life, the feet are more satisfactory for appraisal of bone age because more ossification centers appear at an earlier age than in the hand. Associated radiographic views will be governed by the established routines of respective clinics. However, the procedure is always such that comparative views of two similar areas are taken, i.e., both hands, both feet, both forearms, etc.

Another survey that is done on a combined system of bones is that which is done on the vertebrae of the spine. This examination will very often use a before and after series. That is, prior to the utilization of shock therapy on very severe psychoneurotic patients, a request may be forwarded to the X-ray clinic for a PST or a PEST depending on which abbreviation is preferred for the preelectrical shock therapy. When such a request is received, it indicates that spine radiographs should be taken of the lumbar, thoracic, and cervical areas. Usually PA and lateral views of the skull are also included. The specific views taken of the individual areas again will be governed by the clinical routine. Many times after the patient has undergone the shock therapy, he will again be returned to the X-ray clinic for the same views to be repeated. These two series of views are taken primarily for two reasons. The first reason is for the safety of the patient in that the X-ray will allow the attending physician to decide whether the patient is capable of undergoing the shock therapy by elimination of any spinal injuries through the interpretation of the radiographs. The second reason is more a medical legal element in that there is positive proof by means of X-rays, that there was no injury on the patient before his therapy and there was none after his therapy. Both are very important to all concerned.

The long bone survey is usually done for the purpose of diagnosing malformations of long bones caused by either disease or a retarding and/or stoppage of the normal bone growth process. The patient will usually exhibit various symptoms such as curvature of the extremities (bowlegs, knock-knees, etc.) or a shortening of one of the extremities. When shortening does occur, differentiation can be established as to whether the shortening is functional or anatomical. This is accomplished by measurements of both related extremities to determine actual figures. An antomically short extremity will show a shorter measurement of the bones than the other; whereas, a functionally short extremity, usually due to occupation or bad posture, will have the same bone measure as the other comparative extremity. The shortening in the latter case is due to the carrying angle of the body. It is, therefore, seen that a long bone series is a comparative study always radiographing both related extremities. This comparative study also holds true for the aspect of disease of the long bones.

The best method of comparing long bones radiographically to determine their dimensions is by a procedure called scanography.

Scanography is performed in several ways to acquire a true and accurate measurement of long bones in the upper extremity as well as the lower extremity. Very seldom will this procedure be done for the upper extremities. Since we are more interested in the walking extremities, we are primarily interested in the regions of the hip, femur, knee, leg, and ankle.

There are only four methods of scanography that we wish to discuss in order from seldom used to most often used. First, there is the method called slit scanography. This method utilizes a slitlike beam or radiation to scan a part as the narrow beam is moved over it, in the direction of its long axis, for length measurement. The exact length of the part is projected onto the film with no distortion. A five to ten second exposure is used. A smooth tube movement must be accomplished to prevent a stroboscopic effect. The speed of the tube movement must be varied to accommodate the part thickness; slower movement over the hip and femur region and faster as you move down the extremity. If the tube movement cannot be varied, the MA can gradually be reduced and the part becomes thinner, or have the cassette lined with three different screens. (High speed for hip region, medium for knees, and slow for ankle region.) The motor from a standard tomographic unit can be used for this purpose by disconnecting the Potter-Bucky attachment.

Secondly, there is the method of spot scanography where a closely coned exposure is made over each joint, reducing the amount of radiation to the patient. Simply take coned down exposures of the hips and knees on one film so a measurement can be taken, and coned down views of the knees and ankles on another film. The disadvantage is that you are taking a total of eight exposures.

Third, the oldest of the methods introduced as far back as 1924 is orthoroentgenography. Here we use a cassette long enough to accommodate the entire extremity. A single exposure is made at an FFD of 7 feet. Today, the same method is used at a FFD of 6 feet with a finely graduated metal ruler.

The last method is just a modification of the old orthoroentgenographic method. This method seems to be the most practical for it is most widely used. A graduated metal ruler is taped to the table with the patient lying on it with his heels placed on 0 cm. Only three exposures are made. (One-third of the film while the other two-thirds of the film is masked off). Usually a 14-by 17-inch film is used in the Bucky. Each exposure is taken on one-third of the film of both joints simultaneously for bilateral projections. (Hips, knees and ankles.)

These various surveys are performed routinely in large Army X-Ray clinics. If you are to properly perform your duties as an X-ray specialist, a thorough knowledge of each survey is essential.

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE & SURGERY
X-RAY BRANCH

*LP 38-520-127
046

Bronchography and Fluid Levels (1 hour)

COURSES PRESENTED TO: Radiographic Procedures (Basic), 313-91P20

PLACE: Classroom

REFERENCES:

TM 8-280, pp 14-31 thru 14-35

STUDY ASSIGNMENT: After class read TM 8-280, pp 14-31 thru 14-35.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280

TOOLS, EQUIPMENT, AND MATERIALS: None

PERSONNEL: One instructor (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Radiographs of fluid levels and bronchograms; radiographic illuminators, chalkboard, chalk, pointer, and eraser.

TROOP REQUIREMENTS: None

TYPE OF INSTRUCTION: Lecture

I. INTRODUCTION (5 min)

   A. Opening Statement: When performing radiographic examinations of fluid levels in various parts of the body, specific rules must be followed in order to produce the desired end result. During this period, these rules will be discussed as well as the technical aspects for demonstrating specific structures of the lungs by means of bronchography.

   B. Objectives

      1. State the rules to be followed when doing fluid level examinations.

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*This Lesson Plan supersedes LP 38-520-127, 074.

1575

2. State the methods of patient preparation for bronchograms.

3. List the two primary methods of introduction of the contrast medium and the contrast media used for bronchography.

4. Given radiographs of a bronchogram identify the structures demonstrated in bronchography.

C. Class Procedure and Lesson Tie-in

None

II. EXPLANATION (35 min)

A. Fluid Level Examinations

1. Definition

2. Purpose

3. Clinical procedure

a. Horizontal central ray

b. Contrast media

QUESTION: Why must a horizontal CR be used?

ANSWER: A horizontal CR must be used because this is the only one that will successfully demonstrate a fluid level.

4. Paranasal sinuses

a. Contrast media introduction

b. Positions

c. Contrast media

QUESTION: What important consideration must be followed with a contrast medium?

ANSWER: It is used only in a body area where it will drain out naturally or where it can be manually drained.

5. Interpleural space

a. Costophrenic space

b. Contrast media introduction

c. Position

d. Pleural thickenings

QUESTION: Why would a contrast medium be introduced into the interpleural space?

ANSWER: To differentiate between free fluid and pleural thickening.

6. Radiograph of the chest

B. Bronchography

1. Definition

2. Purpose

3. Patient preparation

a. Diet restrictions

b. Local anesthetic

c. Cannula or catheter or trans-tracheal

NOTE: The oral cannula is the preferred method for introduction of the contrast media.

QUESTION: Why is diet restriction important in this examination?

ANSWER: The patient will have a contrast media introduced into his bronchial system. A diet restriction will greatly reduce the amount of vomitus if he should become ill.

4. Clinical preparation

a. Contrast media

b. Sterile materials

c. Exposure room

QUESTION: Why is it necessary to use sterile material for this examination?

ANSWER: To avoid possible contamination of the patient's bronchial area.

5. Fluoroscopic procedure

a. Patient positions

   b. Contrast media introduction--Dionosil

   c. Limited examination

QUESTION: Why is this method for bronchography rarely used?

ANSWER: The patient is exposed to an excessive amount of radiation.

6. Radiographic examinations

   a. Positions

   b. Patient handling

   c. Wet readings

QUESTION: Why must the patient be cautioned against coughing during the entire procedure?

ANSWER: Excessive coughing will expel the contrast medium and additional medium would have to be introduced.

7. Precautions

QUESTION: Why do we never leave the patient unattended?

ANSWER: The patient has been administered an anesthetic and is groggy. If left unattended, he might fall and injure himself.

C. Questions From Students

NOTE: After class assignment: Read TM 8-280, pp 14-31 to 14-35.

III. **SUMMARY** (5 min)

A. Review of Main Points

   1. Definition and purpose

   2. Basic principles

   3. The contrast media

   4. Methods of introduction

   5. Fluoroscopic and radiographic examination

   6. Precautions

B. Closing Statement: Fluid level examinations and bronchography are done regularly in X-ray clinics, thus, necessitating a thorough understanding of both of these procedures.

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE & SURGERY
X-RAY BRANCH

*IM 38-520-127
046

Bronchography and Fluid Levels

When performing radiographic examinations of fluid levels in various parts of the body, specific rules must be followed in order to produce the desired end result. During this period, these rules will be discussed as well as the technical aspects for demonstrating specific structures of the lungs by means of bronchography.

The collection, dispersion, shifting, or superimposition of free fluid with structures within the cavities of the body often require a special technique for X-ray demonstration. To determine the amount of fluid within the body cavity along with the probable cause of the fluid, a fluid level examination is performed.

Fluid level radiography is the examination of the cavities of the body for the amount of free fluid contained therein.

The purpose of fluid level examinations is usually to differentiate between two possible existing elements: (1) to differentiate between pleural thickening and free fluid when examining the inter-pleural space; and (2) to determine the amount of fluid contained within a cavity in order for a decision to be made as to whether manual drainage should be done, or whether a body is capable of absorbing the fluid contained without the aid of aspiration.

There is one prime rule which must be constant while performing fluid level examinations. The central ray must be kept in a horizontal position. Also, the CR should be parallel with, or at the same elevation as the plane of the fluid level.

Fluid level radiography may be accomplished with the patient in the erect, supine, prone, lateral, or decubitus positions.

Paranasal sinus examinations are usually done with the patient erect in front of an upright table or vertical Bucky. If no contrast medium is to be injected, it is advisable to wait a few minutes for the fluid within the cavity to stabilize before accomplishing the examination.

When a contrast medium is injected into the sinuses, care should be taken to be sure that the injected medium is not expelled by the patient. Some gauze, around the tip of the syrings being used will usually be sufficient to keep the fluid from being expelled by the patient.

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*This IM supersedes IM 38-520-127, 074.

After the medium has had time to stabilize, routine upright sinus examinations are performed.

Occasionally, the patient will report to the X-ray clinic with the medium already injected. The Specialist in this instance, need take only routine sinus radiographs utilizing the upright position.

Occasionally, a substance called Thorad is used in sinus examinations. This substance forms an insoluble albuminate when it comes in contact with the mucous membrane of the sinuses. Due to its great opacity to X-ray, Thorad gives a very good outline of the sinus tracts. However, due to its insolubility, this substance can never be used in an area that does not have continuous drainage.

In fluid level examinations of the interpleural space, the areas most commonly under concern are the areas that lie on the lateral aspect of the lungs called the costophrenic sinuses (angles). Due to the location of these sinuses, in regard to man's upright position, fluid will usually collect in these areas.

Occasionally, use of a contrast medium may be necessary for visualization of a suspected fluid in these areas. In such cases, the medium is injected through the chest wall directly into the costophrenic sinuses.

Often, because of the similarity of the densities on the resulting radiographs, it will be necessary to differentiate free fluid from pleural thickening. To complete the examination, a radiograph will be taken with the patient in the laterally recumbent position. The side under consideration will be nearest the table and buttressed up off the table so the image produced can be projected on a vertical film. This position will allow the fluid to flow along the chest wall and be recorded in a different area while pleural thickening will remain in the sinuses.

These examinations are often requested after pulmonary complications, thoracic surgery, and gun shot wounds.

Bronchography. The lungs are areas of high susceptibility to pathology and because of this, they are constantly visualized via routine chest radiographs, but if disease is still suspected, the inner structure of the lungs must be examined. This is accomplished by use of a contrast medium in conjunction with chest radiography. The examination of the lungs and bronchial trees containing a contrast medium by radiologic and fluoroscopic means is called bronchograp[illegible]

The purpose of this examination is to diagnose tumors or other diseases of the bronchi of the lungs, to visualize any bronchial obstruction, and to investigate the pulmonary cavities.

1581

The X-ray clinic, upon receipt of a properly completed request, will schedule the examination in accordance with established routine.

In some cases, the patient is allowed a light breakfast on the day of the procedure. In any case, nothing by mouth is permitted (except for medical reasons) for at least 8-12 hours prior to the examination.

When indicated, postural drainage and/or bronchoscopy is carried out on the ward the morning of the examination.

The throat passages of the patient are anesthetized by spraying with a weak cocaine solution prior to the examination. This prevents the patient from gagging and deadens the cough reflex.

The drugs used to stop the gagging and coughing may produce considerable drowsiness in certain patients. The X-ray Specialist, therefore, should afford proper consideration with respect to the patient's state of alertness, especially when in the darkened room during fluoroscopy. The Specialist should carefully assist and reassure the patient during this step in the procedure.

Next, an oral cannula, or a catheter, is inserted directly into the glottis to facilitate the injection of the contrast media to be used. The medium is then induced according to predetermined procedure. The oral cannula is the preferred method for introduction of the contrast media.

When a catheter is used, the examiner will use either the oral or nasal approach. The tube will be inserted until it is at the upper level of the trachea. Then under fluoroscopic control, the tube is maneuvered to its proper position.

If the catheter or cannula fails, the transtracheal method is used whereby an intercatheter is placed into the midanterior neck and introduced into the trachea as far as possible.

During the fluoroscopic procedure, the patient is usually positioned according to the dictates of the examiner. Various positions of the patient are incorporated to use the influence of gravity to allow the contrast medium to reach the area of the lungs to be examined.

In some instances, the act of tilting the table to a desired degree may be of considerable advantage, for example, in the event of filling the upper lobes of the lungs. Here a modified Trendelenburg Position is used during the injection of the contrast medium.

After positioning, a limited fluoroscopic examination is made to determine if the contrast medium is entering the proper lobe and outlining the specific bronchioles under consideration. Fluoroscopic spot films in various positions may be taken.

Upon completion of the fluoroscopic procedure, the Specialist must take radiographs of the patient. All care must be taken to insure that the patient does not gag or cough before completion of the radiographic examination.

The projections to be taken are usually determined by the examiner. These positions include PA's, laterals, obliques, and occasionally, stereo views.

When taking these radiographs, the patient is usually instructed to carefully take in a deep breath and hold it, then the x-ray exposure should be executed without delay. Should the patient be unable to restrain the cough reflex, the X-ray Specialist should attend him promptly. He should instruct the patient to take in shallow, short, but rapid breaths and not to swallow. An emesis basin with cleansing tissue should be kept handy into which the patient can expectorate.

Immediately upon completion of the radiographic examination, the patient should be permitted to lie down and be made comfortable until the bronchogram films have been developed and checked by the examiner. After the films have been checked and further x-rays are found unnecessary, the patient is encouraged to cough and rid himself of as much of the contrast medium as possible. The patient is then returned to the ward where postural and/or tussive drainage, if necessary, is carried out.

During this period only the bare essentials were discussed. Remember the one most important factor in the radiography of fluid levels is that the X-ray Beam MUST be in the horizontal relationship to the floor. The importance of exposing the films for bronchography at the proper time must be constantly kept in mind.

Fluid level examinations and bronchography are done regularly in X-ray clinics, thus, necessitating a working knowledge of these examinations by the prospective X-ray Specialist.

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE & SURGERY
X-RAY BRANCH

*LP 38-520-124
036

Pediatric Radiography (1 hour)

COURSES PRESENTED TO: 313-91P20, Radiographic Procedures (Basic)

PLACE: Classroom

REFERENCES: TM 8-280

STUDY ASSIGNMENT: After class Review TM 8-280, pp 13-1 to 13-3.

STUDENT UNIFORM AND EQUIPMENT: TM 8-280

TOOLS, EQUIPMENT, AND MATRIALS: None

PERSONNEL: One instructor (X-Ray Branch) (MOS 91P2H or 91P4H)

INSTRUCTIONAL AIDS: Infants; and children's radiographic films; chalkboard, chalk, eraser, pointer, and radiographic illuminators.

TROOP REQUIREMENTS: None

TRANSPORTATION REQUIREMENTS: None

TYPE OF INSTRUCTION: Lecture

I. INTRODUCTION (2 min)

A. Opening Statement: In the military as in the civilian X-Ray Clinic, children form much of the patient load. Children are unpredictable, exuberant, and restless. No standard adult positioning technique is really going to hold a child still on your table. Therefore, special infants; and childrens; techniques have been adopted to provide you with the ability to consistently produce diagnostic films. During this hour we will discuss these procedures and how you can apply them.

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*This lesson plan supersedes LP 38-520-124, 015

B. Objectives

1. Adjust the technical factors to achieve diagnostic films while working in Pediatric Radiography.

2. Identify and utilize accessory devices to immobilize children for X-Ray examinations.

3. List the factors which cause pediatric radiography to be different and more difficult than the normal radiographic procedures.

C. Class Procedure and Lesson Tie-in

None

II. EXPLANATION (38 min)

A. Equipment

1. Modern machine

2. mA (200+)

3. kV (40 to 70)

4. Exposure duration

a. Minimum time

b. Motion

(1) Voluntary

(2) Involuntary

QUESTION: What do we as technicians have available to us to control involuntary motion?

ANSWER: Short time of exposure.

B. Accessories

1. Head holders

a. Soft rubber

b. Radiolucent material

1585

2. Sheets
    a. Elevate infants
    b. Wrap around for immobilization
3. Cassette holder
    a. Open end
        (1) Foot end table
        (2) Arms around holder
    b. Riding type (toy)

C. Psychological Considerations

1. Gaining the child's confidence
    a. Approach
    b. Understanding
2. Fear
    a. Equipment
    b. Hospital personnel
3. Pain
    a. Location
    b. Aggravation
4. Accidents
    a. Falling from table
    b. Small objects

1586

5. Environment

   a. Strange location

   b. Unfamiliar persons (white uniforms)

   c. Darkness (fluoroscopy)

D. Physical Factors

   1. Size of child or part to match film size

   2. Susceptibility to infection

      a. Cleanliness

      b. Masks

E. Preliminary Procedures

   1. Select factors

   2. Film

   3. ID

F. Positioning

   1. CR to part

   2. Part to film

   3. Bilateral extremities

QUESTION: Why should we x-ray both extremities?

ANSWER: For comparison

4. Positioning problems
    a. Inspiration
    b. Expiration
    c. Uncooperative children
        (1) Minimum cooperation
        (2) Restraint
            (a) AP
            (b) PA

G. Immobilization Aids and Methods
1. Assistants
    a. Patients
    b. Ward attendants
    c. Nurses or professional personnel
    d. Parents
    e. X-ray personnel
2. Methods
    a. Cotton web strap
    b. Sponges
    c. Sheets

H. Precautions
1. Leaded aprons
2. Leaded gloves
3. Shielding
4. Colimation

5. Unattended patient

6. Diaper pins

I. Contrast Media

NOTE: Show contrast media films and explain the following:

1. G.I. series

NOTE: Explain use of nursing bottles and flavoring when working with children and infants.

2. Barium swallow

3. Barium enema

J. Technique Factors

K. Questions From Students

NOTE: Make assignment: Study TM 8-280, pp 13-1 to 13-3

III. SUMMARY (5 min)

A. Review of Main Points

1. Equipment

2. Accessories

3. Physical factors

4. Preliminary procedures

5. Positioning

B. Closing Statement: Pediatric radiographs can be the most exasperatingly difficult and at the same time the most rewarding work that an X-ray Specialist may become involved in. As you have seen, children pose many technical and procedural problems for you. But, the feeling of accomplishment you will get when you aid in the diagnosis and treatment of these little people will make it all worthwhile.

1589

ACADEMY OF HEALTH SCIENCES, US ARMY
DIVISION OF MEDICINE & SURGERY
X-RAY BRANCH

*IM 38-520-124
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Pediatric Radiography

In the military as in the civilian X-Ray Clinic, children form a large part of the patient load. Children are unpredictable, exuberant, and restless. No standard adult positioning technique is really going to hold a child still on your table. Therefore, special infants' and childrens' techniques have been adopted to provide you with the ability to consistently produce diagnostic films. During this hour we will discuss these procedures and how you can apply them.

One of the first problems for you to solve is to select technical factors that will produce radiographs with minimum unsharpness, average densities and contrast. Such techniques can be worked out satisfactorily for infants and children on any modern X-ray diagnostic machine with a capacity of 200 or more milliamperes. The most expensive equipment is not essential. You may choose preliminary technical factors for all body parts from the infants' and children's technique chart. Slight modification of this chart may be necessary depending on the machine. If you find it necessary to make a factor change a small increase or decrease of the kilovolts is recommended which would eliminate a MAS adjustment. The exposure time must always be of the shortest duration possible to control motion which is found to be both voluntary as well as involuntary. Normal respiration will quickly reveal its effects as will normal pulsation and peristalsis motion of the stomach and intestines. You will find motion a more difficult factor to control than in adult radiography.

The technical factors given in TM 8-280 have been found in practice to give satisfactory diagnostic radiographs from birth to 12 years of age. Should you find it necessary to increase the exposure times it will, of course, cause a loss of image sharpness.

There are five simple devices which can be used as an aid in immobilizing infants and children during radiography. They can be stored in any radiographic room; First, straps of web material 2 inches wide and 2 to 3 feet in length may be used to hold the head still in various positions. Heavy sandbags can be placed on the ends of the strap or held by adequately protected hands of an assistant well out of the field of radiation. Second, head holders manufactured by the Picker X-ray Corporation or General Electric X-ray Corporation will be found invaluable with your paranasal sinus routine. These accessory devices may be used with the patient either in the prone, supine, or erect position. The radiolucent padding attached to the device will case no image on the film and will offer protection to the patient's tender skin surface.

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*This instructor's manuscript supersedes IM 38-520-124, 015

Third, sheets can be folded and wrapped around children for use where vertical positions are required with the use of a horizontal central ray. Fourth, open end cassette holders are most desirable for subjects as difficult to handle as most children who resent being positioned against anything as solid as a wall. An open end type cassette holder permits the child to sit with his legs extended beyond the holder and with his arms wrapped around the cassette, thus, moving the scapulae forward and out of the lung fields. Some of you will experience clinics currently using a cassette holding device situated near the front of a toy horse. This tends to speed examinations.

Among the most important factors you must learn in connection with the handling of infants and small children when carrying out various radiographic procedures, is that of gaining their confidence and cooperation. This is often a rather trying and difficult undertaking. However, if you will approach each child with a generous fund of patience and make a sincere effort to understand their reactions, you will become better capable of producing radiographs of high quality with the least waste of time and with minimal stress or confusion. Fear in an infant is variously tied in with the instinct of self-preservation. You will see displays of pain. If the pain is localized in the region of the skull, site of recent surgery, or site of trauma in any region of the body, you must handle the child with decorum in order not to aggravate the condition. You are cautioned against leaving the small patients unattended on X-ray tables. It would be most unfortunate for you to have to X-ray a child's broken arm or leg resulting from a fall when he originally came for just a PA of the chest. Almost any type of noise is frightening to a child in a strange location. You will therefore avoid sliding the Bucky tray into position with a slamming action, banging cassettes or incidental items of accessory equipment on or near the X-ray table. You must consider the child's environment, he is in a strange place, and among strange persons and equipment. You will keep the child in the comfort temperature range, by avoiding cold drafty areas, cold cassettes, and equipment. You will be aware of a child's apprehension when examinations are being carried out in a darkened fluoroscopic room.

The size of the patient generally will determine the size of film employed. You must always give this consideration before going to the ward for bedside radiography. You may, under certain conditions be required to utilize a shorter focal film distance, this affords certain advantages in that it will not produce excessive image distortion, and, moreover, the shorter FFD will permit the use of shorter exposure items.

In each case you must wash your hands thoroughly before handling any pediatric patient. The table top and cassettes which the patient may come in contact with should be carefully cleaned before use. Clean towels should always be placed on the table top or over the cassettes on which the patient is to be placed.

You may call the ward for pediatric patients only at times when you can give them immediate attention. You will then prepare the radiographic room by having the films and other necessary preparation ready before the patient is brought into the exposure room.

For the most part, positioning procedures for pediatric patients should conform to the essential technical considerations such as the CR to part and part to film relationships as prescribed for the customary or standard positions. When possible you must avoid awkward positions and take advantage of unorthodox angulations or positions of the X-ray tube. Except with specific instructions, complete the examination of the extremities bilaterally, preferably by simultaneous exposure on the same film. You must keep in mind two of the most difficult clinical problems dealing with infants. First is inspiration; how do you inform an infant to cooperate on inspiration or expiration. This is accomplished through visual observation. Second is motion, through mostly voluntary means which will quickly render your film useless. The most effective method for overcoming these two major problems is to watch the patient closely and use the shortest possible exposure time.

The assistance of one or more persons other than another technician, should be enlisted for the purpose of immobilizing the patient according to the demands of a particular situation. We have already discussed the methods used under accessories.

You will provide lead impregnated aprons, gloves and other suitable shielding for protection against irradiation for persons who assist with immobilization of the patient during exposure. You must use colimation properly to confine the area of irradiation to the most practicable limits. Under no circumstances will you hold the patient during an exposure. Under no circumstances will you leave the child unattended on the X-ray table or in the crib with the guard railing down. The danger of the child falling is too great a risk. In the event you have your patient immobilized you must make a final check just prior to exposure insuring that the assistant's hands or other objects are not superimposed with respect to any area of the patient being exposed. You will be responsible for keeping loose articles, such as pins, identification materials, etc., which may be swallowed, out of reach of the child at all times. In children where verbal communication is no problem, your instructions with respect to breathing control should always be carried out in the simplest manner and in the shortest possible time. The attention given to any one thing by children, as a rule, is very short-lived. In the case of infants, when necessary, crying may be induced and the exposure made at the "beginning" of the cry.

For gastrointestinal (GI series) examinations in the case of infants, approximately 4 ounces of barium sulphate suspension composed of equal volumes of barium sulphate powder and 5% sterile glucose water should be prepared in a sterile nursing bottle. You must maintain a supply of several sterile nipples with openings of different sizes to meet the demands of particular situations. You will carry out the preparatory phase of the examination in accordance with your clinic policy. Usually, food and fluids are withheld approximately 4 hours prior to examination. Incidental fluoroscopy and radiography is done according to the directions of your radiologist. When dealing with children over 2 years of age, for the most part, your handling will be done similar to the adult examinations. You will carry out the esophageal studies with the same contrast media as used for gastrointestinal examinations. You will aid in the introduction of the contrast media from the nursing bottle or by way of a suitable catheter attached to a syringe which has been transnasally inserted into the esophagus. The radiographic portion of this examination is usually limited to spot filming of which you will be largely responsible for the quality of those films. We can see from the appearance of the esophageal study of this infant that the esophagus is fully demonstrated and well filled. For barium enema examinations, you will mix a suspension consisting of equal volumes of barium sulphate and water and introduce this material through the anus by means of a suitable catheter under fluoroscopic control. You will use adhesive tape to hold the buttocks together for contrast substance retention. Incidental radiography or spot filming will be carried out according to the desires of your radiologist. The procedural and technical rationale for other contrast studies, such as bronchography, intravenous and retrograde pyelography, cystography, urethrography, pneumoencephalography, ventriculography, etc., in pediatric patients is essentially no different than in the adult patient. The main exception in regard to the above is that the amount of contrast media and film size are scaled to size or age of your patient. In certain examinations with infants and children under 5 years of age much of your fluoroscopic and radiographic work will be done with the patient in a horizontal position.

Pediatric radiography can be the most exasperatingly difficult and the most rewarding work that an X-Ray Specialist may become involved in. As you have seen, children pose many technical and procedural problems for you. But, the feeling of accomplishment you will get when you aid in the diagnosis and treatment of these little people will make it all worthwhile.